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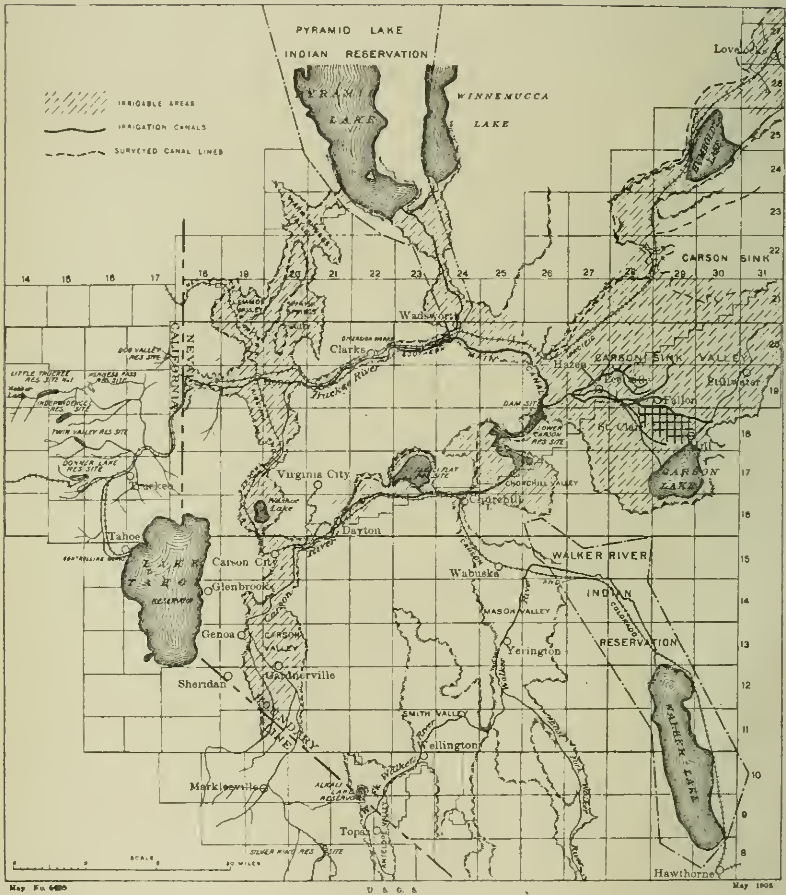

U. S. G. S.
RECLAMATION SERVICE
TRUCKEE - CARSON PROJECT NEVADA
GENERAL MAP

JOURNAL
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VOL. CLXV, No. 1 83RD YEAR JANUARY, 1908

THE FRANKLIN INSTITUTE.

(*Stated Meeting held Wednesday, December* 18, 1907.)

Nevada, the Silver State, and Government Irrigation in Nevada. The Truckee-Carson Project.*

BY PROF. OSCAR C. S. CARTER.

The Reclamation Service were fair in giving Nevada the first chance at irrigation, and starting promptly in September, 1903, to build a canal thirty-one miles in length to divert water from the Truckee River and convey it to the channel of the Carson River, where finally a storage reservoir will be built. This canal, together with 270 miles of lateral ditches, is completed, and, according to the Reclamation Service, in June, 1905, occurred the final opening of this project, the first to be constructed under authority of the law of June 17, 1902. If ever a State needed irrigation, that State is Nevada. The greater part of the State is as absolute a desert almost as the Sahara, and the rainfall corresponds closely with that region, being from two to ten inches per year. Moreover, what little rain falls does not fall at the time of year when it will do much good, namely, at the time of growing crops. Rain is most needed in the summer season, not the winter, but the rain shows a pronounced maximum during the winter season in that part of the Great Basin region known as

*Read by title.

Nevada, and they get twelve times as much rain in January as they do in July at the Winnemucca, which is about the center of the region. In order to conduct agriculture here successfully and raise fair crops at least twenty inches of rain per year are required. It may be a little less will suffice if it falls at particularly favorable times, but when the rainfall is less than twenty inches per year we cannot raise abundant crops without irrigation. Even trees require for successful growth from twenty to twenty-five inches per year. It is very evident that Nevada cannot rise above the mining stage of prosperity without irrigation. Her brief but remarkable history clearly shows this. No State can be prosperous on the mining industry alone, because when the mines give out, the people leave, because it is impossible then to make a living where agriculture cannot be successfully pursued. The past history of Nevada as a State is the history of the Comstock Lode, the present history of the State is the history of Goldfield, Bullfrog and Tonopah. You cannot separate the mining industry from the history of the State. The Comstock mine built cities, erected telegraph lines and helped to build transcontinental lines, but when the mines were practically exhausted the population dwindled down to about 30,000, which was about one-half the former population of the State. The present gold excitement at Goldfield, Bullfrog, and Tonopah has brought about 15,000 new comers to Nevada. Let us hope that this will be a permanent population and not a population of floaters. When the gold mines give out, and that is the history of all gold mines, let us trust that there will not be the exodus from the State that there was in the seventies, but that the thousands of acres made fertile by irrigation will furnish permanent homes to settlers. This is the more to be desired because Nevada is a State and sends two Senators and a Representative to Washington, and yet the population for a time was 30,000, not equal to some of the inland country towns of Pennsylvania. and

EARLY DISCOVERIES. COMSTOCK LODE.

New Jersey. How like a story from the Arabian Nights reads the discovery and history of the Comstock lode which since the discovery, in 1859, has yielded $200,000,000 in silver and gold and made Nevada a State. James Finney, known as "Old Vir-

ginny," was a native of Virginia. He was a roaming prospector and sort of a human divining rod in whom the miners had much faith. While prospecting over the hills north of Gold Cañon, he was attracted by the appearance of a ledge of rock on the slope of Sun Peak. He climbed up the rocks and wrote a notice of his claim on a piece of paper and hid it in a crevice in the rock. His claim was recognized by the miners although he never attempted to develop it. Virginia City was named after him. Two prospectors by the name of McLaughlin and O'Riley were washing dirt on the slope of the hill with poor results. A little stream of water trickled down the slope, but it was not large enough for them to use their rockers. Accordingly they began to dig a water hole on the side of the Sun Peak where they could use their rockers to wash the earth from the heavy gold scales. The earth thrown out was a yellow sand, pieces of quartz and a black mineral they had never seen before. When they washed this yellow sand in the rockers and the mud washed away they found the bottom fairly glittered with scales of gold. Even with their rude appliances they were quickly making a fortune. The great lode had been tapped again. The facts from which this brief narrative is written are found in the monograph of U. S. Geological Survey on Comstock Mining and Miners, to which the reader is referred for a fascinating account in charming English. A loud-mouthed trickster got the credit for this great discovery of the greatest mine of modern times. The true discoverers, Finney, McLaughlin, O'Riley, Orr and the Grosh Brothers, are to fortune and fame unknown. The Comstock lode is famous throughout the world. Henry Comstock was a tall Canadian fur trader and trapper, who finally wandered to Nevada and prospected around Gold Cañon. He took the vacant cabin of the Grosh Brothers, and two Indians worked his claim while he wandered around. On the evening of the day when McLaughlin and O'Riley made their rich discovery, Comstock came riding over the hill. He saw the limits of their claim and the rich find they had made, and running up to the rocker he ran his hand through the dirt and observed the bright spangles of gold. He then informed them that they were working on his property and that he had taken up a ranch of 160 acres, and their claim and rocker were within his boundary. This was an absurd claim to make, as it was a barren peak and there was no grass for grazing.

He had no title to his claim and no record of his ranch. The land was Government land and was open to anyone who would stake his claim and work it. Comstock finally pursuaded these innocent men to give up part of their claim to himself and his friend. He also made claim to the little stream that trickled down the slope where they had their washer, claiming that it flowed from a stream higher up on his claim. He finally obtained from them a grant of 100 feet on the rich lode providing they could enjoy the water equally. Comstock and his new partners finally concluded that they would conceal their rich find, so they filled up the hole and concealed traces of their work. Their

reason for doing this was, the miners were about to have a meeting and formulate laws for their own government, and also laws for the recording, locating and holding of mining claims. Article 4 had twenty sections, and makes interesting reading at this late day. The Recorder was to keep a well-bound book in which a record of all claims, names of parties locating, the number of feet in claim, and where situated were recorded. Section 11 stated, "No Chinaman shall be allowed to hold a claim in this district." The State of California afterward recognized to a certain extent these laws, and declared they might be offered in evidence in all controversies respecting mining claims, and furthermore that they should govern the decision of the action when not in conflict with the Constitution or the laws of the State. It must be understood that these men were removed from civilization and laws governing criminals, and mining laws were necessary. The Vigilance Committee rode one morning through the valley of the Carson and caught a gang of alleged cattle thieves and murderers. Three judges presided over the trial and lynch law justice was administered; one was hung in another locality after trying to get the names of his companions. Another of the party who owned a station house in the valley was led to execution singing the "Last Rose of Summer," and adjusted the rope about his own neck. Others were fined or banished. This is merely a type of rude frontier justice that prevailed in other States than Nevada. After the miners' meeting, Comstock and

GREAT VALUE OF THE ORE.

his partners staked off their claims and additional ones for discovery. While mining they neglected the black mineral ledge in the center of their claim as worthless. One day a ranchman of Truckee River meadows gave a piece of this black mineral to an assayer. The result of his test showed a value of $3000 in silver and $876 in gold per ton. This black material proved to be argentite, or sulphide of silver. The development of the great Comstock Lode dates from this discovery. Comstock was persuaded to make over his claim to a speculator from California, but his companions jeered him so that he determined to get it back. Accordingly a jury of miners made up of Comstock's friends, gravely decided to give it back to him, as they resented any interlopers from California.

Comstock, however, did not keep his claim very long, but sold it to James Walsh. For $10,990 he and other speculators bought up the other claims. Five-sixths of the location, or 1,166 feet, were sold for $70,601, at the rate of about $60 per foot. Thirty-eight tons of ore were sent across the Sierras to San Francisco, which yielded when smelted $112,000. Comstock and his original partners drifted away, their fortunes were soon spent, and they returned to prospecting the hills and ledges for more gold. After interminable litigation the section became unproductive. Miners were no longer plentiful and the hot water in the shafts discouraged them. This was the condition of affairs when four

MACKEY, FAIR, FLOOD AND O'BRIEN.

miners of experience, who were also daring speculators, determined to get possession of the mines and various claims and also get satisfactory titles. These men were Mackey, Fair, Flood, and O'Brien. Mackey and Fair were born in Ireland. Mackey was a ship carpenter, and drifted to California, where he learned practical mining, as did Fair. Flood was the financier of the party. A large and deep shaft was projected by Fair, over $200,000 were spent searching for the bonanza and the treasury was empty. When the shaft was 710 feet deep the ore vein had widened to twelve feet. When 1500 foot level was

reached the richest ore was met with. Drifts were cut into the mass hundreds of feet and passed through rich ore, 1000 tons of which were taken out daily. As the mine became deeper the Director of U. S. Mint and Prof. Robert E. Rogers, in 1875, estimated that the ore in sight was worth $300,000,000. The stock that brought $1 per share in 1870 brought $176 in 1874, and in 1875 brought $700 per share. The drop came later when, as usual, many fortunes were lost. Hot water began to accumulate in the lower shafts in such enormous quantities that the enormous steam pumps could scarcely cope with it. Mr. Adolph Sutro

SUTRO TUNNEL.

was the leading spirit and promoter, who conceived the idea of driving a tunnel in the foot hills of the Virginia Range to the Comstock Lode. This tunnel was to be about 20,489 feet long—nearly four miles. The height of the tunnel was to be ten feet at first and the width was to be thirteen feet. After reaching a point about a quarter of a mile from the mouth the tunnel was to be five feet wide by six high. This was afterward enlarged by an Act of Congress, calling for an area not less than eight by eight feet. It was determined to sink four ventilating and working shafts at intervals of about a mile, so that the work could be carried on at the same time at different shafts, and when the level of the tunnel was reached a number of men could be at work driving the tunnel at the same time. Senator Stewart was president of the company, but their financial difficulties were disheartening. They wanted to raise $3,000,000 by subscription to build the tunnel, and Eastern capitalists were slow to invest. They promised to invest however if he could start the enterprise in the West. He finally succeeded in getting the mining companies to subscribe $600,000, but they annulled their subscription and the New York capitalists promptly did the same. He visited London and the various European capitals, and tried again New York and Washington and finally was successful. While driving the tunnel the rocks became very hot, and when near the Savage mine the rocks in the tunnel had a temperature of 114°, but when the tunnel was completed and drainage channels cut to the different mines, the drainage water reached the temperature of 137°F.

During the year of 1881, over 4,752,605 tons of water drained from the Comstock Lode through the tunnel. It was used for irrigation in the valley and for driving a turbine wheel. Before the tunnel was completed the estimated cost was $3,000,000, but it was built for about $2,000,000. It has been estimated that 600,000,000 feet of timbers have been used in the mines, enough to build a town of 30,000 six-room, two-story frame houses each 40x25 feet. During twenty years 140 miles of mine galleries were opened by holders of claims. Along the line of the Comstock Lode cities were built containing a population of 20,000. The output of the mines up to 1881 was 7,000,000 tons of bullion worth $306,000,000.

MINERS.

During the year 1880 more than 2770 men were employed at the mines. They were Americans, 770; Irish, 816; English, 640; Canadians, 191; Scotch, 83; Germans, 55; Welsh, 34; Italians, 14; only 2 Russians and 1 Slav. Other nationalities were represented, but in small number. These figures are interesting for comparison with the numbers the various nations of Europe send to-day. These miners worked naked in the mines, having only a breech-cloth to covei the hips and thick soled shoes to protect them from the scorching rocks.

HOT WATER.

It was first thought that the high heat was due to chemical combination of the lode rocks and the hot water; for example, the change of the lode feldspar into kaolin, but this was disproved and the cause seems to be due to the fact that the eruptive or lava rocks have not lost their temperature yet. It never impressed the mine owners and miners that some of the hottest water might be utilized to heat the houses of the nearby towns in winter. Perhaps the hot water system was not developed then and doubtless they were too busy making money to think of other matters. The highest temperature of the water noticed up to 1877 was 154° Fahr., but when the Yellow Jacket shaft was finished a stream of water having a temperature of 170° Fahr.

was met with. Tons of ice were lowered in the mine and ice water drank in large quantities, and it is stated that one man would drink three gallons during a shift of eight hours. A miner who breathed for some time air, the temperature of which was 128° Fahr., was carried fainting to the surface, babbling like a child, having lost his memory temporarily. Another miner working on the 2000-foot level refused to go to the cooling station when warned by his companions. They were not surprised to see him drop his pick and fall dead. Three miners while climbing up a winze from the 1900-foot level were asphyxiated by the terrible heat and foul air; a thermometer registered 135° Fahr. where they died. A misstep would plunge them into hot water which would cause the skin to peel off with fatal results. They were exposed to fearful drops of temperature, because after suffering from the intense heat while working stark naked and the perspiration oozing from every pore, they would be whisked to the surface and exposed to the chilling blast of winter. Pneumonia was a common disease among the miners.

WAGES.

All underground laborers were paid at the rate of $4 per day, no matter whether they were shovelers or pick carriers. Modern methods seemed to prevail among the miners, and when one company held out against the wage rate, a committee was appointed to confer, but this committee consisted of 300 men, who marched to the mine and persuaded the foreman to bring up all the miners so they could ascertain if any were receiving less than $4 per day. Some shovelers admitted receiving less, but the foreman could not persuade the committee that they should receive less on account of the kind of work. Their demand was the same rate for all men working underground, no matter what the work.

FATE OF DISCOVERERS.

Fortune never favored and prosperity never followed any of the first discoverers of the Comstock Lode after their first great find. Finney lost what little money he had and made a poor living selling mining claims. He came to an untimely end by fall-

ing from his horse and fracturing his skull. Comstock, the adventurer, bought a wife from a Mormon for a horse, a revolver and sixty dollars, but she ran away at the first opportunity. He then opened supply stores in Carson City, failed and again became a prospector. His early successes and great hardships turned his brain and he wandered from camp to camp and finally committed suicide. O'Riley lost his money and wandered away from Nevada, but returned again and started to tunnel a foot hill of the Sierras, which was mainly rotten granite. He said the spirits told him there was a mountain of silver and gold ahead. He worked there alone by the light of a candle muttering to himself. The mine caved in on him and when he recovered he was sent to a private insane asylum where he died. McLaughlin, who was an honest, industrious man, had poor luck and finally served as cook for a party of miners. He died in a hospital without enough money to pay for his funeral. Ill luck seemed to pursue these men, while the good fortune of Mackey, Flood, O'Brien and Fair, the final owners of the mine, is known at home and abroad. Agriculture, through irrigation, must, after all, be the hope of Nevada. The county in which the Comstock Lode is located had a population of 16,000 in prosperous times when the mines were paying, but in 1900 it had dwindled to 3,600.

TONOPAH AND GOLDFIELD.

We are afraid history will repeat itself in the case of Tonopah, Goldfield and Bullfrog. When the mines cease to pay, the miners and gold seekers will leave and finally the merchants, and these towns will share the fate of Virginia City. Tonopah lies far to the southeast of the Comstock Lode. The Southern Pacific R. R. connects Tonopah and Goldfield, and Bullfrog is seventy miles east of Goldfield. Tonopah is the oldest of these three very new towns and had a population of several thousand. The pack trains and prospectors got their supplies there before wandering across the desert in search of gold. Goldfield, just sprung into existence a year or so ago, has five hotels, two daily papers, several banks and many other banks of another kind. The population is over ten thousand. Bullfrog, the youngest mining camp, now

a town, has a hotel, electric light plant, newspaper and an expensive water system, and by this time several thousand inhabitants.

They have rapid transit across the desert now. The day of the stage coach, pack train and burro (out little long-eared friend that carries everything and has been called the ship of the desert) has not yet passed by any means. They have automobile lines from Tonopah to Goldfield to Bullfrog, and you are whisked across the desert in a couple of hours and pass the slow moving pack train that makes the same journey in three or four days to Goldfield. A new railroad has been completed connecting Salt Lake City and Los Angeles. It runs through the heart of this mining region. It is said that Borax Smith, of California fame, will build a road through Death Valley in California to connect with Bullfrog. This road will begin at Daggett, on the Santa Fe system, and will also cross the Mojave Desert. Death Valley will be shorn of many of its terrors, some of which are fanciful, when this new line is finished through the valley. The last link of still another trans-continental system will pass from Salt Lake across central Nevada and over the Sierras to the Pacific. When all of these roads are completed Nevada will have a better chance than she ever had before. Another difficulty that Nevada had to contend with in the past was the disposition of the public lands, amounting to about 2,000,000 acres. Congress gave Nevada power to select and dispose of this land as the State saw fit. It is said the Legislature put the land up for sale and the stockmen practically got control of it, naturally selecting sites along the rivers and water holes, which water supplies they could more or less control. This was of course a check to settlers who wished to make a living by farming, which could only be carried on by irrigation.

TOPOGRAPHY AND CLIMATE.

Before explaining the "Truckee, Carson Government Irrigation Project," let us look for a moment at the topography and climate of the State, a clear understanding of which is necessary before the planning and final disposition of any irrigation scheme. Nevada lies wholly in the Great Basin Region. This is an area

between the Sierra Nevada Mountains, of California, on the west and the Wasatch Mountains, of Utah, on the east. It also takes in Southern California and Southern Arizona. Although it is called a Great Basin, it is in reality a plateau in Nevada from 4,000 to 6,000 feet above tide, but it is not a flat plateau. It is covered with from forty to fifty parallel ranges of mountains in Nevada, all trending north and south. These ranges have nothing whatever to do with the Rockies. They are supposed to be fault blocks, due to a break in the strata; one end was pushed up, the other dropped. So that many of them have a long gentle slope on one side and a precipice on the other. The reason it is called a basin region is, the Sierras on the west tower high above the entire region and the rivers that are formed by the melting of the snows in the Sierras, flow down the eastern slope into the basin and never reach the ocean. They either evaporate or sink into the desert and are lost to view. Some of them empty into large shallow lakes that are slowly drying up under the influence of the hot dry air. Other streams entirely disappear during the hot summer. The only large river that reaches the ocean is the Colorado, which is not fed by the Sierras but which receives its supply from the rains and melting snows of the Rockies. The little arable land in Nevada along the rivers supports no timber growth except cottonwoods. The eastern slope of the Sierras contain valuable forests of coniferous trees. The Sierras are high enough to receive sufficient rainfall to support timber growth. On the other mountains the timber depends on the altitude. The lower ranges support a growth of cedar, pinion and manzanita, which does not amount to much. The higher ranges have better timber. The scenery of the Great Basin is characteristic desert scenery. Russel compares it to the parched and desert areas of Arabia and to the shores of the Dead Sea.

The traveler from the East misses the green of the upland and meadow, and the resident of Colorado misses the wide open grassy parks of thousands of acres between the high mountains. The rainfall is but from two to ten inches per year, and as remarked before, it comes in winter when the crops don't need it much. The annual rainfall near the canal at Wadsworth is six inches per year; at Reno, on the Truckee River, the rainfall is about eight inches; at Verdi, near the California line, at higher

elevation, 15 inches per year; at Carson, 12 inches; at Virginia City, in the mountains at an elevation of 6242 feet, the rainfall is seventeen inches. The figures on the desert and in the valley where irrigation will be practiced may be accepted at two to ten inches per year and on the mountains higher As a consequence of this deficient rainfall the air is remarkably dry and the snows seldom lie in the valley more than a day or two. The maximum temperature is from 100° to 111° Fahr. In summer the nights are cool. The winters are dry and pleasant. Like other parts of the arid West, Nevada contains large areas of grazing land notwithstanding the extreme aridity. This grazing land is not equal, however, to parts of the Great Plains east of the Rockies. When the 12th Census was taken an estimate was made of the number of cattle in the different States and Territories. Texas had over 9,000,000 cattle, Kansas over 4,000,000, Nebraska over 3,000,000. Nevada only had at that time 386,249 cattle. Of course the area of grazing land is small compared with other States and the population was and is small. The valleys, though desolate and of little value for agriculture without irrigation, are covered with sage brush, desert shrubs and some bunch grass, all of which form a pasture better in some places than others.

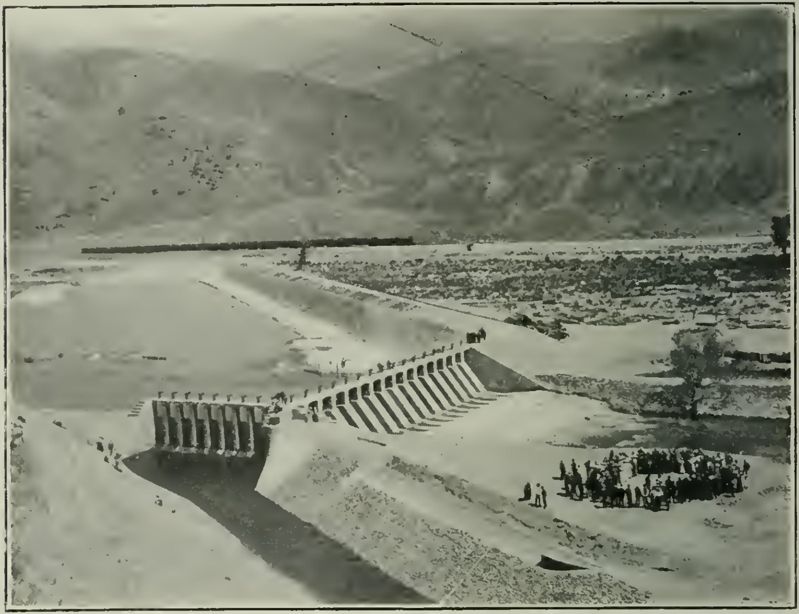
TRUCKEE-CARSON PROJECT.

The water that is to irrigate Nevada comes from the Sierra Nevada Mountains, in the western part of Nevada and the eastern part of California. The rains and the melting snows of the Sierras drain into Lake Tahoe, one of the largest mountain lakes in America, 6225 feet above sea level. The greatest depth of Lake Tahoe is nearly 2,000 feet. The greatest length from north to south is twenty-one and a half miles. The greatest width is twelve miles. The Sierras tower high above the lake. This lake is to furnish the water for the Truckee-Carson project, but unfortunately the boundary line between California and Nevada passes through the lake, so that two-thirds of the lake is in California, therefore Nevada has not sole control of the lake. California cannot well use the lake for irrigation because that part of the State is in the Sierras and is very rocky, but the mountains near the lake once had a heavy growth of timber and the Cali-

fornians floated the logs down the lake into the Truckee River, where they built a dam and saw mills run by water power. The Truckee River drains this lake, or better, it is the natural outlet for it, and the river after leaving the lake flows northward for a distance of thirty miles or more through California with a winding course. It enters Nevada near Verdi. In the mountains it is fed by a number of small streams. When the river enters Truckee Basin it flows towards the east for a distance of forty-five miles. In this part of its course it passes through Reno Valley and Lower Truckee Cañon to Wardsworth. It then flows about twenty miles northward and empties into Pyramid and Winnemucca Lakes. About thirty miles south of the Truckee River is the Carson River. The project is to build a canal thirty-one miles in length (now completed) from the Cañon of the Truckee near Wardsworth to the Carson River. This canal will take the flood and excess waters of Truckee River that would otherwise be lost in Pyramid Lake and Winnemucca Lake and carry them in a southeasterly direction to a reservoir site on the Carson River. Into this reservoir site will also pour the excess waters of the Carson River. From the reservoir distributing canals can be built to cover, according to the Reclamation Service, several hundred thousand acres of land near Carson Sink. A number of reservoir sites for the storage of the waters of the Truckee and Carson Rivers have been surveyed. The Reclamation Service realize that the simplest plan from an engineering standpoint is to utilize Lake Tahoe, but they say that owing to legal difficulties it has not been deemed wise to begin at the upper end of the river, the reason being that part of the lake is in California. The Reclamation Service in January, 1906, issued the following statement:

NEVADA: TRUCKEE-CARSON PROJECT.

"When completed it is believed that this system will provide an ample supply of water to irrigate about 350,000 acres of arid land in Western Nevada. The first work of actual construction was begun in September, 1903, on a canal thirty-one miles in length to divert water from the Truckee River and convey it to the channel of the Carson River, where a storage reservoir



Opening of Truckee project, June 17, 1905, by Congressional commission.

Congressional party investigating the newly completed head-works on the Carson River, June 17, 1905. Truckee-Carson project.

Looking west up Truckee canal from top of tunnel 2 in division 2, showing a completed portion of the cement lined canal. Sta. 389+04.

A completed portion of cement lined canal just below the east end of tunnel 1 in division 2. Truckee-Carson project, Nev.

eventually will be built. This canal, together with about 270 miles of lateral ditches, is completed, and on June 17th, 1905, the third anniversary of the Reclamation Act, occurred the formal opening of this project, the first to be constructed under authority of the law of June 17th, 1902. Water is now ready for delivery to about 50,000 acres, 30,000 of which are public lands, which have been thrown open to homestead entry, and may be filed upon by bona fide settlers, in accordance with the rules and regulations of the homestead laws and Reclamation Act. The lands are tributary to the Southern Pacific and the Nevada and California Railroads. An assessment of $26 per acre will be charged against the land for its water right, payable in ten annual installments without interest. Maps showing the location of available entries may be inspected at Carson City, Nevada, land office, where application should be filed. The construction of outlet and regulation works at the outlet of Lake Tahoe and the extension of the system to include additional areas will be undertaken at an early date."

Although the final plan is to reclaim 350,000 acres of land, the immediate plan is to reclaim 200,000 acres in Carson Sink Valley, north of Carson Lake. The small town of Fallon is about in the center of the area to be irrigated. The following description of the main features of the irrigation system is taken from the fifth annual report of the Reclamation Service:

"(1) A main diversion canal for carrying the waters of the Truckee River over the low divide to the Carson Basin and thence around the west side of the valley to Carson River at the dam site for the Lower Carson Reservoir; (2) main distributing canals for diverting water from Carson River below the reservoir to the principal bodies of land in Carson Sink Valley; (3) the lateral distributing system for the further distribution of water to the lands to be reclaimed; (4) the conversion of Lake Tahoe into a reservoir with a capacity of 200,000 acre-feet for holding part of the water; (5) a reservoir with an approximate capacity of 220,000 acre-feet in the Alkali Flat site north of Carson River for storing surplus water from Carson River; (6) the building of the Lower Carson Reservoir by which 286,500 acre-feet of the combined waters of the Truckee and the Carson may be stored.

"The Truckee Canal is designed to carry about 1200 second-

feet of water from the Lower Truckee Cañon into the Lower Carson Reservoir and about 200 second-feet to a point in the cañon convenient for a branch to the Pyramid Lake region.

DIVISIONS OF CANAL.

"The canal is 30.9 miles long and is divided into three divisions. Division 1 extends from the head to the 6-mile point; division 2 extends from the 6-mile point to the 13-mile point, and division 3 extends from the 13-mile point to the end. An important part of division 1 is the diversion dam and headworks. There are several expensive concrete structures on divisions 1 and 2, and on division 2 are three tunnels. Division 3 is entirely in open country. All structures are of Portland cement concrete and iron or steel, no wood being used except for minor parts such as flashboards.

DIVERSION WORKS.

"The headworks consist essentially of a diversion dam across the river and of headgates at the entrance of the canal. The diversion point is in the cañon about four miles east of Clarks and five miles above Derby, both of which are stations on the Southern Pacific Railroad. It is about ten miles westerly from Wadsworth, which is on the Truckee River. The elevation above sea level at the region of the dam is about 4200 feet. The dam and headgates are built as one structure of concrete, reinforced in places. The dam runs squarely across the river, while the headgate is placed at right angles to the dam, extending up stream from the south end.

DAM.

"The dam is designed for the passage of water through it similarly to a headgate. It is 155 feet long between abutments. From the main foundation arise fifteen piers to serve as posts for the regulating gates, sixteen in number. The foundation is 8.83 feet thick, and thirty feet wide, up and down stream, by 171 feet long over all. It rests on the natural bed of

East portal of tunnel 3, division 2, Truckee canal. Truckee-Carson project, Nev.

Steam dredge in operation, loading cars on banks of Truckee canal. Truckee-Carson project, Nev.

Looking down the Truckee canal through one of the rock cuts at Sta. 45 in division 1.

View looking southeast down the valley, showing a long stretch of Truckee canal under construction. Truckee Carson project, Nev.

light gravel and bowlders. No effort was made to reach solid rock, as it was not necessary. The excavation was carried to an average depth of about five feet below the bed of the river, which is about 145 feet wide. The main piers are fifteen feet high, the top being at high water mark. On the top of each is a smaller pier for the support of the gear for lifting the gates. The smaller pier is 5.25 feet long, 2.5 feet wide and 7.33 feet high. Two lines (157 feet each) of 7-inch beams, 15.3 pounds weight, spaced seven inches between webs, run through the coping of the piers and extend along the line of the gate shafts. These beams support the lifting gears and serve to re-inforce the concrete arches that extend from pier to pier. There are sixteen gate openings, each five feet in the clear, between the river piers. Each gate is composed of three sections: (1) The lower gate, used alone for the ordinary regulation of water; (2) the upper gate, called into action only when a large amount of water is required to pass; (3) the flashboards, which may be removed for the passage of extreme high water. The lower gates are of cast iron, the body being $1\frac{1}{4}$ inches thick and strengthened by radial ribs at 45° intervals. They are five feet seven inches wide by five feet high. The upper gates are cast iron, the body being one inch thick and reinforced by shallow outside and cross ribs. The gates proper are five feet nine and one-quarter inches wide by five feet three inches high. The maximum discharge of the river is probably 10,000 to 12,000 second-feet.

HEADGATES.

"The row of headgates extends up stream from the south end of the dam at an angle of 90°. The supporting structure is an extension of the south abutment of the dam. There are nine gates spaced seven feet between centers and each having a clear opening of five feet. The distance between the end walls is sixty-one feet. The framework of the structure supporting the gates is of steel and consists of eight posts and one main girder. The main girder is at the top above the gates and spans the space between the end walls. Each gate has only two flashboards of only eight-inch width. The sill of each gate is a four by four-inch timber set flush in the main concrete sill. This sill is two feet and three

feet eight inches above the bed of the canal and the floor of the dam. This is to favor the sluicing through the dam of sand and silt that accumulates in front of it. The bed of concrete here is about six feet deep. On the side next the river a curtain wall or cut-off wall of average thickness of fifteen inches is carried down to the same level as the bottom of the foundation of the dam.

TRUCKEE CANAL IN TRUCKEE CANON.

"The portion of the Truckee canal in the cañon represents the most difficult work and the greater part of the expenditure. It includes all of division 1 (six miles) and four miles of division 2. The sides of the cañon slope for the most part at angles ranging from 5° to 30°. The formation is heterogeneous, consisting of earth, gravel, talus, cemented material of various kinds and several kinds of rock. There is considerable calcareous tufa and some very coarse sandstone. The only real hard rock found is a kind of trap rock. The formation is so much broken or open and porous that it is not well adapted for holding water. The only clayey matter present is a fine silt, a characteristic deposit in the old lake beds of all this region. It is the only natural substance available for puddling or for silting up the sides and bottoms of canals.

CONCRETE LINING.

"Concrete lining is used under a variety of circumstances. (1) In rock excavations it is employed to make a smoother section and thus allow a narrower cross section and consequent reduction in yardage. (2) It is used in light porous materials and in very broken seamy or fissured rock in order to prevent leakage; and (3) it is employed in places where leakage or washouts might have serious consequences. The standard thickness of lining used was generally about six inches, but in one place four inches was adopted. It was possible to use four inches where the rock was not too much shattered or too rough. All lining is brought up to an elevation two feet above water line, at the grade for top of banks. The amount of concrete per linear foot of canal varied all the way from 0.6 cubic yard to 1.4 cubic yards,

U. S. Reclamation Service.

Lower Carson reservoir site, looking southwest from the dam site.

A dam in Truckee River at Lake Tahoe.

depending on width and slopes and on the thickness of lining. On the section with twenty feet width and one-half to one slopes, a thickness of six inches requires one cubic yard. The total cost to the Government of all items for the concrete was about $9 per cubic yard.

TUNNELS.

"There are four tunnels on the Truckee Canal, all on division 2. As the material to be encountered was known to be variable, three methods of lining tunnels were prescribed in the specifications: (1) Temporary timbering was put in during excavation and the permanent lining of concrete was put in afterwards, the timbers remaining in the concrete. (2) No timbering was put in or the timbers were moved when the tunnels were lined with concrete. (3) In hard rock the tunnels were plastered with a coat of cement plaster. The finished section of concrete by either methods one or two is twelve feet wide, twelve feet high to the springing line and has a three centered arch 3.35 feet high. The water section is thirteen feet deep. Tunnel No. 1 is about 6½ miles from the head of the canal. It is 901 feet long between portals. Under natural conditions this tunnel would not have been built, though it saves much side hill work and some distance, but the location of the railway required it. The material encountered is a dark, hard flinty rock with many seams and slips. The greatest height to the surface of the ground over the tunnel is probably as much as 200 feet. Tunnel No. 2 is about 7.4 miles from the head of the canal. It is 308.7 feet long all on tangent and the portal cut has a length of about seventy-five feet. The topography here determined its use, aside from the obstruction offered by the railway to an open canal. This tunnel was constructed without timbering. The material encountered was a red rock not hard but compact, tough and without seams, so that it broke up short in blasting and could be cut close to line. The greatest elevation of the surface over the tunnel grade is only 58 feet. Tunnel No. 3 begins 8.5 miles from the head of the canal. It is 1,515 feet long. The portal cuts are about thirty-five and forty feet long at the upper and lower ends. The greatest vertical distance from the tunnel grade to the surface was just 100 feet The material driven through was earth all

the way and no powder was used. For about 150 feet of the exit end (east end) there was a loose sand without admixture of adhesive materials, which ran very freely, and the difficulties were so great that the progress with two shifts was less than one foot per day. Tunnel No. 4 is located 7.6 miles from the head of the canal. It is required to pass the water of a wasteway at this point under the railway track to discharge into the river.

U. S. Reclamation Service.

View looking east from head of Emerald Bay, Lake Tahoe.

The water drops down to the head of this tunnel from the wasteway through a shaft forty-nine feet deep.

TRUCKEE CANAL BELOW TRUCKEE CAÑON.

"At a point about ten miles from the head works the canal reaches the end of the Truckee Cañon and comes into a wide valley. Here the work was much simpler and easier and no structures were required. The canal lies on the gentle slope

which has tapered out from the foothills. The canal discharges into Carson River, near the dam site for the Lower Carson Reservoir, at a point 30.9 miles from the head. This terminal point is a little west of south of Hazen, and seven miles distant.

DISTRIBUTING CANALS.

"The main distributing canals form the second essential part of the Truckee Carson project. Their office is to divert the waters from the Carson River to the main bodies of land to be irrigated. At present the principal body of land is that south of Carson River in the neighborhood of Fallon. The diversion for both sides of the river is made at a point about four miles above (west of.) Leetville post office and five miles below the dam site for the Lower Carson Reservoir. The canal on the south side of the river was designed to have a capacity of 1500 second-feet and that on the north side of 450 second-feet. The lateral system is for the subdivision and conveyance of the water in the main distributing canals to the land to be irrigated, including in most cases the delivery at the higher side of each farm unit. The irrigable lands in the Carson Sink Valley have been divided into seven divisions or districts, each containing 20,000 to 50,000 acres. Each district will have a system of lateral distributaries and necessary waste ditches or drains.

PYRAMID BRANCH CANAL.

"Six miles from the head of the canal, at the end of division 1, there is provided a take-off for the canal which is to serve the Pyramid Lake area. This consists essentially of: (1) A set of head-gates (more properly check-gates) in the main canal. for use in holding back the water when required to give a good head for turning it into the branch canal; (2) the head-gate of the branch canal itself; (3) the supporting structures, approach section of canal, etc."

FRUITS AND VEGETABLES.

The same fruits that grow in Pennsylvania can be successfully cultivated on these Truckee farms, apples, peaches, pears, plums

and cherries, also the smaller fruits, as strawberries, raspberries, gooseberries and blackberries. All the cereals can be grown in abundance, particularly wheat. Corn is a profitable crop also. Alfalfa it yields five tons to the acre. All the common vegetables find a ready market in the mining camps or can be shipped to San Francisco, as can the fruits. This land will not fall into the hands of speculators or corporations, because a man to own eighty acres must live on it and he must visit it first and inspect it before he files his application. He cannot file an application if he owns 160 acres elsewhere. Foreigners who have not declared their intention of becoming citizens cannot secure land, neither can minors or married women, except where the husband is disabled. When persons secure Government land they are expected to live on it and cultivate it.

VERIFICATION OF ARTESIAN WATER PREDICTIONS IN CENTRAL SOUTH DAKOTA.

The great practical value of the underground water investigation of the United States Geological Survey has recently received another demonstration—this time in central South Dakota. In this region the western extension of the Northwestern Railroad system from Pierre to Rapid City has built up the valley of Bad River, and the company has sunk three wells to supply water for locomotives and other uses. In sinking the wells the company was guided entirely by a map published in a report on the geology and underground water resources of the central Great Plains, of which South Dakota forms a part, published by the Survey as Professional Paper, No. 32. This map, prepared by Mr. N. H. Darton, the author of the report, indicated in a general way the areas in which artesian flows might be found and showed the probable depths at which the great water-bearing formation of the Great Plains, known to geologists as the Dakota sandstone, would be reached. The predictions made by Mr. Darton on this map were very closely verified by the railroad company's wells. At Capa, where the top of the Dakota sandstone was shown by the map to be at a depth of about 1510 feet, it was found at 1500 feet. At Nowlin farther up the valley, the depth predicted was between 1500 and 2000 feet, or approximately 1750 feet, and the water-bearing Dakota sandstone was entered at 1760 feet. At Wendte, twenty miles west of Pierre, a similar verification of prediction was made.

This is but one instance of many that might be cited in which the water investigations of the Survey have resulted in the successful location of artesian wells.

At Panama.*

By Fullerton L. Waldo, F.R.G.S.

Lieut.-Col. George W. Goethals, U. S. A., Chief Engineer of the Isthmian Canal Commission, reported on December 4 to the Washington office of the Commission that the total excavation for November was 1,838,486 cubic yards, making a daily average for 24 working days of 76,600 cubic yards. Five cubic yards of earth and rock, such as the great ninety-five-ton Bucyrus shovels grub up at a single bite, after the side of a hill has been "shot" or blasted, weigh from seven to nine tons, so that it is safe to say that a daily average of something like 120,000 tons is being hauled seaward on the rocking Western dump cars or being plowed off by the Lidgerwood unloaders from the dirt-trains into the abysmal reek of primeval morasses and the jungle. The French, at their best, were taking out something like 1,500,000 cubic yards a month, twenty years ago. So that in actual cubic yardage we are exceeding the achievement of our predecessors, and the prophecy, which a year ago seemed over-sanguine, that the canal would be ready for commemorative expositions at Los Angeles and New Orleans in 1915, bids fair to be fulfilled.

One of the most interesting books that has ever been written on the Panama Canal is the Report, just issued, of the Canal Commission for the year ending June 30, 1907. The pictures bring the graphic exposition of the conditions much more nearly down to the present date (some bearing the legend September 10, 1907), and make plain the connection between paving and self-respect in the cities; between the adequate housing of the work-

*A lecture delivered before the Franklin Institute, Friday, November 29th, 1907.

ing-corps and a degree of contentment hitherto supposed to be unrealizable on the part of Northerners living in the tropics; between an adequate supply of filtered water and mortality-rates that would be the pride of a New York or Philadelphia Board of Health. No before-and-after-taking advertisement could exhibit more sudden or surprising metamorphoses than this Annual Report represents, and the result of its perusal must be to establish unshakeably the confidence of the reader in the work and in the men who are doing the work. If other evidence were needed that the dirt is flying and that the filth has flown,—that the Isthmus is livable for white men,—that while the great dam at Gatun slowly but surely rises against the chocolate torrent of the Chagres, and the giant cleft in the hills at Culebra grows steadily wider and deeper, the children are going to school and women are marketing much as they do at home—if one wants additional evidence that the American community has transferred American institutions to the Isthmus little altered, one has only to read every week the pages of the *Canal Record*. There he will find the unbiased chronicle of the life of the thirty thousand people of the working community. He will learn there how the surveyors in the Chagres Valley have come upon a little French village under the *bejucca* vines and the white orchils, with machine shops whose clinking and purring tools have given place to the strident voices of the paroquets and the jabber of monkeys. He will learn there of judges and lawyers soberly holding court for undesirable citizens and meting out even-handed American justice. He will find contract vs. day labor discussed, and the scores of a woman's bridge-whist club duly held up for emulation. He will learn of Japanese teas and Spanish classes, baseball and bowling alleys, and Thanksgiving pumpkin pie. There are "letters from the line," about how small boys scraped the frost from the pipes of the cold-storage plant and snow-balled each other,—about a challenge to a walking match across the Isthmus, or the Continent, if you like, some 44 miles of distance,—about the establishment of fraternal orders, with much band music and lemonade. There is one wistful column of the names of those who are going back to God's own country by the constant shuttle of the steamships,—a wistfulness tempered by the welcome extended to those who are coming back to the Isthmus again, after the long vacations granted every employee.

It is good to read about all this, but it is still better to have been down there and to have seen for one's self how things are going, as it is the writer's privilege to have been and to have seen, last winter.

Those who have seen Dwight Elmendorf's lectures with their accessories of motion and color, need in addition little more than six months of dry heat followed by six months of supersaturation, to realize what life at Panama is like. The abominable climate that makes garden vegetables as difficult to raise as little children—that often pulls down the white man's capacity for "virtuous energizing" to the low level of the black man's vegetative existence—that brings green mold on books and ants into the woodwork, and makes taut fiddle-strings impossible—even this climate, if you live as Dr. Gorgas lives, who follows the rules and obeys the laws of tropic nature,—becomes tolerable. That is the first thing, of course, that the new-comer broods about—he is obsessed by fear that the climate will sap and undermine his energy and leave him a prey to Chagres fever or elephantiasis. How do the statistics of Dr. Gorgas' latest health report justify the apprehension? "The sick rate for September," Dr. Gorgas reports, "was 27.78 per thousand, and for August 29.02—a decrease of nearly 2 for September as compared with August. The same rate for September, 1906, was 37 per thousand.

"The number of employees on our rolls on the 1st of September was the largest that has so far appeared on the rolls of the Commission—slightly over 41,000. In September, 1906, we had something over 28,000 employees. Among these 28,000 employees we had 135 deaths, which gave us an annual death rate of a little over 57. In September, 1907, we had 41,000 employees, with 98 deaths, giving us an annual death rate of a little over 28 per thousand—quite a marked improvement.

"Among our 4,200 American employees we had two deaths, giving us an annual death rate of 5.71—about the same as last year.

"In September, 1906, the total population of the zone was 76,000, from which population we had 350 deaths, giving us an annual death rate of a little over 54 per thousand. In September, 1907, the zone population was 108,000, in which population we had 297 deaths, giving us an annual rate of a little over 32 per

thousand, showing a very marked improvement in the death rate, both of the laboring force and the general population.

"No case of either small-pox or yellow fever occurred on the zone during the month."

So much for the health of the zone—that ten-mile wide strip which includes the axial line of the Canal and is deflected at either end to skip the cities of Colon and Panama, but not the American suburbs of these cities,—Cristobal and Ancon. Cristobal is a delightful place,—like Manhattan Beach, it is swept by ocean breezes, when there are any; it has an ice plant and cold storage and a steam laundry and a bakery of its own, and the cellarless houses reared on posts, and covered from top to bottom with wire gauze against *anopheles* and *stegomyia*—these houses, cleanly and airy, shed the tropic rains from their corrugated roofs, and the porous soil beneath soaks up the flooding waters, and there are no pockets for standing drainage where mosquito larvæ breed. A shell road in front, and the indolent windmill-arms of the cocoanut palms overhead, and the open roadstead of mud-brown shallow water, with the red and rusted tramp steamers lying at anchor off the railway pier—this is the 'long-shore picture; and just behind you, beside the railway track, are the freight yards, and giant scare-crows of the coal unloaders, and the Mount Hope storehouses, partially destroyed by fire the first of last April. And there is the "Monkey Hill Cemetery," with red zinnias abloom, newly-christened Mount Hope, so that people will forget the horrid stories of the French regimé, and how the crew of the daily dead-train dumped the corpses out of the coffins upon the hillside, and sold the coffins again. And beyond that still, is the mighty Reservoir, which Poultney Bigelow could not find, and where the launch named for him is tethered to the bank. The water-works system of Colon, which this Mount Hope Reservoir supplies, is now complete. About five miles of sewer pipe were laid in the year covered by the Annual Report. Seventy-five house connections have been made with the water pipe, 414 service boxes and 122 meters installed. The Mount Hope Reservoir, which was completed in December, 1906, has a capacity of 435,000,000 gallons. In watering and paving the cities of Colon and Panama the United States has thus far expended $1,750,000, which is to be reimbursed by the two municipalities from water-rates collected. In the city of Panama last year some two and a-

half miles of water pipes were laid, 2,093 houses were connected therewith, two million vitrified brick from Dubuque, Iowa, were laid in the streets, and now Panama claims the proud distinction of being the best-paved city between Buenos Ayres and the City of Mexico, with twenty gallons of water per day supplied for each of its inhabitants—many of whom have little or no use for it.

At Colon, where much of the land is only a matter of a few inches above the water, and the soil is a seeping, porous sponge, dredges in the channel are doing most of the work. The dredging fleet comprises one of the old French ladder dredges, a five-yard dipper dredge, and a sixteen-inch suction dredge; more recently, a sea-going suction dredge, like the big dredges in New York Harbor, has been doing yeoman service, adding between three and four hundred thousand cubic yards a month to the sum total. Before this recent acquisition, the excavation for the fiscal year at Colon was eleven hundred thousand cubic yards.

At Gatun, where the railway line must be relocated to swing clear of the vast mass of the dam, is one of the two great present centers of activity, the other being the heart of the Culebra cut. As everybody knows, this dam at Gatun is what the schoolboy would call "the biggest ever." It is not really a dam; it is a hill or mole, or barrow of earth, such as the Ohio mound-builders would have clapped their hands to behold. For a mile and a-half in width it is to reach across the valley, clamping it from hill to hill, and its base a half-mile through, will obliterate the site of the ramshackle, palm-thatched, native village of Gatun, with its little gray Catholic church. The United States will lift those poor little sentry-box houses to the hills, or else rebuild before the village moving-day. And by that great earth-barrow, whose dimensions are only approached, but not equalled, by a couple of earth-dams in California, an immense lake will be created, as the whole world knows, with the top of the dam, a hundred yards wide, fifty feet above the surface of the water at the eighty-five-foot level.

The three locks at Gatun are in pairs; the present dimensions are 1000x100 feet, and there is much talk of widening. On the other side of the Isthmus this lock-flight is counterbalanced by the lift at Pedro Miguel and the two locks at La Boca. The design is simple enough, and the engineering problem at Panama presents quantitative rather than qualitative difficulties. There

Flood of December 8, 1907, on the line of the Panama R. R. at Paraiso.

Freight yards at Mount Hope, just outside Colon.

Native village at Gatun. The village will be razed and its site obliterated by the dam.

The rock cutting at Bas Obispo, the beginning of the Culebra cut.

never has been any reasonable doubt about those famous lock foundations at Gatun. Flurried conjecture in Congress was set at rest, May 2, 1907, by Messrs. Noble, Stearns and Freeman, when they reported: "We beg to record that we found that all of the locks of the dimensions now proposed will rest upon rock of such a character that should furnish a safe and stable foundation." I saw myself, when I was there last winter, the blue-prints of some five hundred borings taken all over the lock site and the dam site to determine beyond peradventure that the dam and the accessory works are not going to shift uneasily upon their bed so as to undo the work of years and render vain the expenditure of millions.

Mr. Ernest Howe, the geologist, makes some interesting and instructive remarks in the Annual Report, anent the nature of the clay beds at Gatun. He says: "The rocks are all well consolidated, though in a few rare cases sandy layers are found which crumble on exposure to the air. These are the beds that have been referred to frequently as 'indurated clays.' The term is a misleading one, since true clays make up but a small part of the formation. Induration is a term applied to the process by which sandstones or argillaceous rocks are converted into quartzites or slates by heat or mineralized solutions accompanying the intrusion of igneous rocks. None of these conditions exist in the vicinity of Gatun. The rocks are of sedimentary origin and were deposited on the sea bottom at some distance from the shore in the form of sands and clays. Their subsequent hardening into rock is the result of simple cementation by calcareous solutions contained in the sea water and through pressure. Certain beds are harder than others, since the nature of their constituents favored more complete consolidation. The beds, however, are not to be regarded as unconsolidated. They are all 'rock,' though in some instances soft enough to be loosened with a pick."

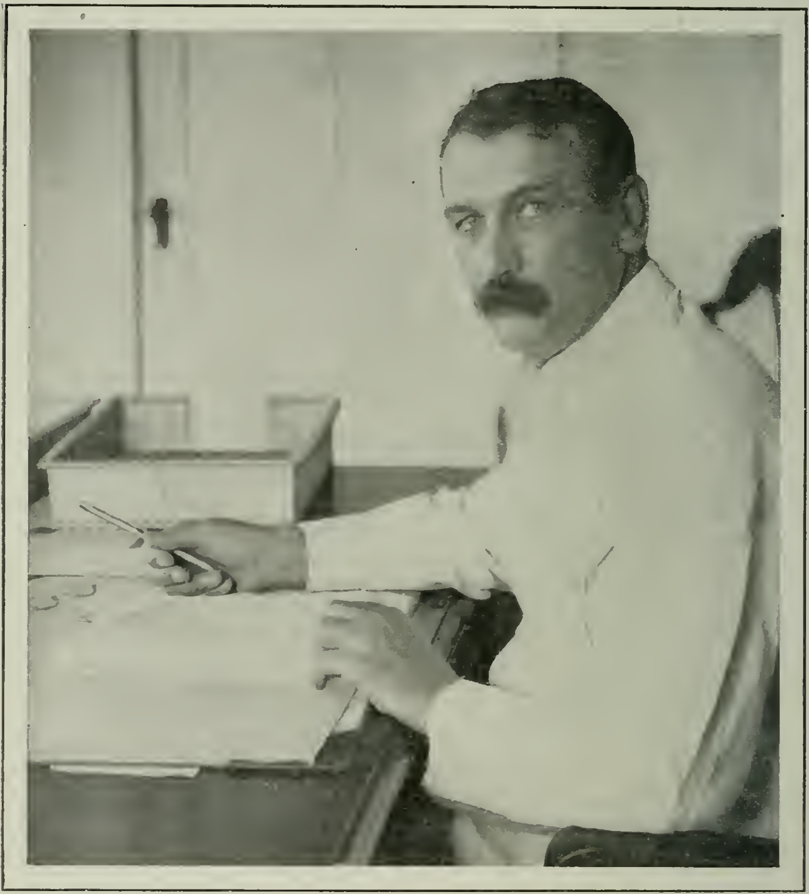
At the other *crux* of the project, the Culebra cut, near six million cubic yards of "spoil" were removed in the fiscal year. The Culebra division is about 10 miles in length, from the Chagres River, which strikes the Canal route amidships, to Pedro Miguel, on the Pacific side of the continental backbone. Last July, in 26 working days, with 43 shovels at work, 770,570 cubic yards were taken out; in August (27 working days and 40 shovels), 786,866 yards; in September (24 days, 39 shovels), the figures were

753,468. This, it must be remembered, was in the middle of the April-November rainy season, when the clay sticks to the dump-cars and the rains send the spur-tracks sliding down the faces of the cut, faster even than Mr. Bierd's wonderful "track-shifter" could transplant them.

The magnitude of the engineering achievement under the French regime will not be depreciated by anyone who has stood on the brink of the cut and watched the buzzards soaring across the abysmal space between Contractors' and Gold Hill. A seventy-ton shovel, plastered against the side of the cliff and fighting away for dear life against the mountain wall, looks about as big as a child's toy fire-engine in a shop window seen from across the street. A ninety-five-ton Bucyrus shovel at work, when you are right up close to it, or perhaps sitting on the boom, is, next to a liner full speed ahead at sea, the most inspiring piece of mechanism I know of. You feel fairly afraid that the mighty proboscis and the sharp, gleaming steel tusks on the lip of the shovel may at any moment turn and rend you, just as they are making ruin there amid the blasted basalt rock and the "indurated" clay. The ropy coils of black smoke wreathe and braid into the lifeless air from the funnel above your head; the machine staggers and rocks upon the rails, and you have to make a megaphone of both your hands for a word to the engineer. And out there on the boom sits a man, paid $190 a month, to pull the latch-rope at just the right instant so that the right mouthful will be discharged with millimetric exactitude upon the dirt train drowsing beside us in the heat-shimmer, till it is given its full complement for the dump, miles distant, maybe. When you have once seen the performance of those shovels, your doubts as to there being a canal some day between those mountain walls are laid at rest forever.

The amount of the excavation at Culebra since the United States took hold of the job (in May, 1903), is as follows, for the year ending June 30: 1904, 60,107 cubic yards; 1905, 741,644 cubic yards; 1906, 1,506,562 cubic yards; 1907, 5,768,014, making a total of 8,076,327 cubic yards. It must be borne in mind that the "lean years" were by no means unproductive, for these years of inconspicuous cubic yardage were the years when the absolutely necessary preliminary measures of sanitation, which the French neglected, were undertaken, while Congress and the newspapers cried out upon the delay in "making the dirt fly." It

was not possible to strike the stride at the very beginning, with thousands upon thousands of workmen to be fed and sheltered and acclimated; with square miles of mosquito-breeding jungle to be mowed away; with a mechanical plant to be installed for the practical solution of an engineering problem of unprecedented



John F. Stevens, Chief Engineer,
succeeded by Col. Gorgas, April, 1907.

magnitude, including the removal of a mountain, picking up a river and throwing it into a basin, and the rebuilding of two cities, all as mere side issues to the main task of creating a strait from sea to sea for more than forty miles.

The highest monthly total of output attained by the French at

Culebra was 502,250 cubic yards, in February, 1886. In April, 1907, the American engineers got out nearly nine hundred thousand,—exceeding by 75 per cent. the record of the Compagnie Interoceanique. About 5,000 laborers, including Spaniards (the Gallegas Spaniards whom George Borrow writes about), Italians, blackmen from Jamaica, Trinidad and Barbadoes, and a few American negroes,—worked at the cut during the year. The Spaniards and the Italians got twenty cents an hour (American money) and the negroes ten. The European laborers are much better workmen than the blacks. The Jamaicans must be cajoled, they cannot be coerced, to do their work; and the kind of work they do is such as no track-foreman in the States would put up with. They stand very much on their dignity as "British objects," and the talk they can "turn loose" when the occasion arises is to the talk of a white man what the Chagres River in flood would be compared with a canary's bathtub.

The question of contract vs. hired labor has been a vexed and vexing one on the Isthmus. In October, 1906, proposals were invited from contractors for taking over the complete construction of the canal according to the Government plans; but upon opening the bids, in January, 1907, none was found to be entirely satisfactory, and the work was retained under the pre-existing government control. The Commission is of the opinion that no one contracting concern is equipped to handle the manifold phases of the work at Panama, including not merely excavation, but dredging, dam-building, lock-construction and the relocating of a railroad. It is also represented that the government enjoys a great advantage over any private contractor in international negotiations necessary to secure laborers who are racially and temperamentally fitted for work under peculiarly trying climatic conditions. The Commission repudiates the assertion that contract labor is less likely to exceed a fixed time limit. They cite the experience of the Commission itself in contracting for supplies in the United States, and assert that the contractors have often exceeded the time limits for delivery, which the contractors themselves have set. Speaking of the Culebra work, the Commission says: "Under the circumstances no advantage would accrue to the United States by letting this piece of work to contractors, but on the contrary there would be not only additional expense, but a

The hospital, Colon.

Paving the streets, Panama.

Bachelor quarters, Culebra.

Old French bucket dredges, Colon.

feeling of unrest and dissatisfaction engendered among the present employees materially affecting efficiency. Under existing conditions, therefore, contract work cannot be recommended for the Culebra division."

The plans for the relocation of the railroad, made necessary in large part by the lake that the Gatun Dam creates, contemplate some two million cubic yards of excavation, and twelve million cubic yards of embankment. The ten million cubic yards of the excess of embankment over excavation will come from the canal prism. A new bridge will be thrown across the swirling current of the Chagres where it elbows to the north at Gamboa. And while at Miraflores and Pedro Miguel and Gamboa and Gatun the new roadbed is being piled into the jungle and the swamp, and the spruce ties from the States and the seventy-pound rails are being laid, the track will be "red-hot" with spoil-trains of Western dump-cars, and passenger trains crowded with black people in transit along the only thoroughfare. When John F. Stevens was "Chief," somebody commented on the number of wrecks. He answered, "Well, that's a sign there are trains running." It has often been said that what with the between-ship passenger traffic, the movement of construction gangs, the transport of material, the dump-trains and dirt-cars, the freight of every description, and the official "specials" white-flagging the way traffic ever and anon, there is no busier section of railroad in the United States than the forty-four miles of track constituting the Panama Railroad. Except for a four-mile stretch between Gatun and Lion Hill, the double-tracking of the road has been completed, and a block system has been installed to facilitate the work of the train dispatcher.

To take a forward look, the estimate of the appropriation needed for the fiscal year, June 30, 1908-June 30, 1909, is thirty-three million dollars. A committee of the House of Representatives, headed by Congressman Tawney, thinks it has found ways and means of saving a million dollars on this estimate, but, as the New York *Sun* has pointed out, the result of the three-day tour of inspection of this party, as compared with the impressive array of facts and figures assembled by the engineers of the Commission, makes a cheeseparing economy appear to be the penny-wise, pound-foolish policy. The Report of the Commission justifies

past expenditures, refutes the critics, and confirms the sanguine prophecies that have been made ever since the first explorers

> "Stared at each other with a wild surmise,
> Silent upon a peak in Darien."

II.

The annual ball of the Culebra club, on New Year's Eve, 1907, at the Tivoli Hotel, in Panama, was a truly brilliant affair; but at midnight while still "to the trembling string the dance gaed through the lighted hall," we left the lights and the laughter, the chiffon and the señoritas, and turned in to try to get a little sleep before the Alligator Hunt, which was due to start at 3 A.M. But just before my head sought the pillow, I stepped out on the verandah a moment in the flooding moonlight. Out on the bay the tranquil brilliant lamps of the big tramp steamers made feeble, ineffectual efforts to mock the starry glory of the Southern Cross; and the arc-lights newly planted along the streets of Panama by *los Americanos* were as if strange constellations had been spilled out upon the land. Up and down the streets the native population paraded, making night hideous with bull-hide drums and tambours and sputtering strings of firecrackers, to which the steam-whistle of the ice-plant added a wailful and long-drawn-out obligato.

At punctually 3 A.M. the black boy beat a rolling tattoo on my door, and I tumbled out. The Captain of Police—who had been up all night quelling chocolate-and-vanilla riots till the exhausted population and the tambours fell asleep over their rum with the gorgeous dawn—had brought the necessary chariots and horses to take the visiting Americans down to the long wharves at La Boca where the big iron ships, rusty from long voyages, come in to discharge their cargoes, and the eighteen-inch white terredo-worms cling with their augur-bit heads sapping away the short-lived creosoted pine timbers.

We drove at a merry rate down the cobbled quagmire of a *calle* in the outskirts of the town, the black boy yelling at his four horses as they waltzed and chassée-d at every shadow, and his long whip rained in viewless fireworks about their metal-tagged ears. He called them all by name; and they whinnied back; and so the talking to and fro betwixt the horses and their driver went

on, till we rounded the big black mole of La Boca Hill in a swirl of dust and came to a hard-breathing pause in the fading moonlight by the stringpiece of the wharf, with the old rotting hulks of French dredges moored alongside.

There the Captain had a big launch ready, the parts of which were sorted out and put together by the canal engineers who found them after the French *débâcle* lying at the top of the Culebra divide among a lot of *snow-plows!* She was a fifty-footer; and with three negroes sweating away in the engine-pit amidships, she took us at twelve brave knots an hour through the islands of the bay, with the sharks chasing the mullet clear out of water, and fleeing schools of mackerel, and pelicans sitting in judicial solemnity on the islet reefs to purse up in their pouchy gullets whatever fish went frantically shoreward among the breakers.

Twenty-five miles from La Boca, we turned and ran in where the ebb-tide was dragging seaward the drug-store chocolate waters of the Chorrera River. Right at the mile-wide river mouth, to the starboard, lay twenty-five feet of a gray-green lichened log, that seemed visibly to cringe and flatten as we ran in nearer for a shot.

The Captain's elephant-gun belched forth like Mount Pelée, and the niggers danced out of the cockpit to clap their hands and shout, as the saurian hove his front half up on pudgy legs, looked about him like a gigantic inchworm, uncertain where to lay hold next, and then shambled and slumped off the mud-flat into the water.

The launch hove to at a tiny dock, and we got into four rowboats, with two Jamaica negroes at each oar. It was a long, slow fight for headway against the current. Three corrugated noses, one after another, ferrying across from bank to bank, vanished ripplelessly under when the Captain, standing in the prow, spoke to them with the elephant-gun. And yet the Captain was not satisfied.

"Just wait till we get around the big bend of the river, boys," he said, "I'll show you a happy hunting-ground then!"

But the big bend might as well have been Cape Horn, so far as our efforts to get around it were concerned. Just here, a reef of oyster-clad rocks ran out into the river, almost from bank to bank, and in the interstices the water combed through, nine miles

an hour. The water-dogs ran out of the thickets to watch us and the paroquets gabbled like gramaphones, and even the buzzards seemed to pause mid-air in their hovering flight, when then saw we could gain no painful inch, and stood practically still amid-stream, with the noon sun blazing down. But our voices disappointed the carrion-hunting birds, in their hopes of finding lifelessness where we were.

"All out on the rocks!" commanded the Captain, and then to the blacks he said, peremptorily, "Take out the guns and the grub, and lift the boat over."

Even then it was not easy. There were bleeding feet among the thwarts when we got in again,—and bleeding hands, too, for those who tampered with the sharp-edged oysters, thinking to make a luscious meal. But with hurrahs and yells we swept gradually round the bend, all four boats abreast, and then—"By Jupiter!" shouted the Captain. On a wide, flat mud-bank to the left was a leviathan convention of about twenty-five (there are those who insist on at least two hundred). The patriarch of the lot lay like a fallen live-oak bearded with Spanish moss and lichens, encrusted with barnacles, hoary with eld. The rest, nestling in his lee, reminded one of a wrecking company's tugs trying to rescue a stranded ocean steamer.

Then it was like the Wild West Show when the Deadwood coach comes in—everyone banging and blazing away in utter disregard of his neighbor,—a dozen 44-caliber Marlin rifles bringing down green cocoanuts on the bank, nicking the bark from floating logs, ruining rare orchids, and driving the astonished sandpipers to their nests among the reeds—only the Captain, standing in the prow of the foremost boat with his elephant gun at his shoulder, his bronzed face impassive, trying to marshal the ague-stricken little army of marksmen, was doing any real execution.

Suddenly there was a stir in the bushes, and a big alligator waddled down the bank toward the Captain's boat, her lower jaw wagging and clapping like the lid of the bucket of one of the ninety-five ton steam shovels in the rock-cutting at Culebra. The Congressman from California poked the nose of his kodak between the Captain's legs. On came the saurian, and the Congressman from California pressed the button again and again. At the last minute, just as the indignant lady 'gator was about to climb into the boat and rebuke the kodak-fiend emphatically, the

Captain fired. The 'gator rolled over into the water, squirming in death agonies, lashing the water into a bloody froth with her ten-foot tail.

"Now, get out there with a rope," yelled the Captain to the bow oarsman, "and make a slipnoose round the upper jaw, and drag 'er ashore!"

The elephant gun spoke again,—she would have dislocated an ordinarily strong man's shoulder with every one of her remarks,—and by the time the boatman's noose was ready the great beast lay quite dead with her back humped out of the shoal water, making a little lagoon betwixt herself and the shore.

The Congressman from California crawled out from between the Captain's legs, and a black bottle with a garish label came rapidly his way from the bowels of the boat.

I saw the photographs afterward, when the Congressman developed them—or it. For it is all one picture. He forgot in his excitement, to unroll the film after pressing the button, and there are more alligators in the composite photograph than there were in the entire herd when the Wild West Show began.

BY-PRODUCT COKE FOR DOMESTIC FIRES.

In a paper read by Paul Schlicht before the Society of Arts at London, May 8, an earnest plea was made for the use of coke in domestic fires, and particularly for coke made in by-product ovens, by which certain quantities of inflammable gas are left in the fuel, rendering it more flaming than that turned out in the ordinary way. The use of bituminous coal in domestic fires was condemned as being very wasteful, for about fourteen times the air necessary to burn the coal was generally sent out the chimney. This is impregnated with steam and sulphuric acid, as well as with particles of carbon, which produced fog. In addition to this, in the consumption of every ton of coal 100 lbs. of coal tar are destroyed; also many valuable constituents useful in the arts and in medicine, besides oils useful for lighting and motor purposes, together with solids that might be employed in road-making. If in place of such form of combustion the coal were treated in the modern by-product oven, there would be, in addition to the products named, about fourteen cwt. of coke, suitable for domestic and metallurgical purposes. Flaming coke can be made in the by-product ovens in from four to five hours less time than the low volatile coke required for metallurgical purposes, a certain percentage of hydrogen and hydrocarbons being allowed to remain in the coke.—*Eng. and Min. Jour.*

(*Stated Meeting held Wednesday, November 20, 1907.*)

"Note on Old Wire Suspension Bridge, Callowhill Street, Schuylkill River, Philadelphia."

By Strickland L. Kneass, C.E.

One of the features of interest to Philadelphians of a generation or two ago, was the picturesque and graceful wire suspension bridge which spanned the Schuylkill River at Callowhill Street, just below the Fairmount Dam and Water Works.

Flanked on the eastern side by the old Water Tower of the Fairmount Reservoir, its graceful outline and easy curves formed a pleasing foreground against the wooded banks of the river. This bridge was designed and constructed by Charles Ellet, Jr., a well known engineer in the early forties, and was built upon the site of the former wooden arch bridge of 340 feet $3\frac{3}{4}$ inch span, ver-sine 35 feet, designed by L. Wernwag in 1812 and destroyed by fire in 1838. The suspension bridge of Mr. Ellet was later replaced by the iron truss, now extant. A preliminary investigation for the erection of the abutments of the present structure, developed some interesting facts in regard to the condition of the Ellet bridge.

At the intersection of Callowhill Street extension and the Schuylkill River, the rock stratum at the western bank is 37 8/10 feet below city datum, necessitating the use of piles for the support of the abutments. The Ellet towers were built upon the old abutments of the 1812 bridge, after a careful investigation had been made as to the security of the piles and grillage. At the eastern approach, the abutments were built directly upon the rock, which at this point is six feet below the datum plane. The square granite towers were 28 feet 10 inches high, 8 feet 6 inches at the base and 5 feet at the top, supporting a cap stone 4 feet 3 inches square, carrying cast-iron rollers for the cables. Five sustaining

cables were provided at each side, 27 feet apart at the center of the span and 36 feet apart between the towers. The wire was made of charcoal iron, manufactured at the Freedom Forge, Mifflin County, Pa.; each cable was 2 21/32 inches in diameter and contained 258 strands of 5/32 inch wire, with a loop at each end which was secured to the anchorage links. At intervals of 18 inches it was wrapped for a distance of 3 inches with fine wire 1/25 of an inch in diameter. The suspenders were formed of wire of the same diameter as those of the main cable, viz.: 5/32 of an inch and in similar way, and consisted of from 24 to 30 strands. The platform was stiffened by a wooden truss of the Howe pattern. When the cables were removed to make way for work on the super-structure of the present bridge, specimens of the constituent strands were sent to the Department of Engineering of the Stevens Institute and were tested by Dr. R. H. Thurston. His report showed that the tensile strength was remarkably uniform and that the surfaces were in good condition and but slightly oxidized. The tensile strength of the wires was found to be 90,000 pounds to the square inch of the original section and were reported to be as good, strong and ductile as the best wire of similar section made at the time of the test in 1875. The tracing herewith shows the details of construction of this bridge, all of which will probably be of interest. Considering the time at which it was built, it shows care in design and workmanship, although it is probable that the link connection between the cables and the anchor chains, could have been more efficiently constructed. This old bridge was a picturesque feature of the Park, and it is unfortunate that during late years but little consideration has been given to graceful lines and æsthetic taste in the design of structures which have since been erected to span the Schuylkill River within the city limits, and thus many opportunities for adding to the natural beauties of our water way, have been lost.

Johnson, Matthey & Co., Ltd., of 48-81 Hatton Garden, London, have succeeded in producing iridium and rhodium of such extreme purity as to render these heitherto practically unworkable metals so malleable as to enable their being used for the manufacture of such apparatus as basins, tubs, and flasks. These metals, having a very high melting point, and being almost unattacked by acids, should prove of gr at value in chemical research.—*Eng. and Min. Jour.*

ELECTRICAL SECTION.

(Stated meeting held Thursday, October 10, 1907.)

(Concluded from vol. clxiv, p. 459)

The Electro-Thermic Production of Iron and Steel.

By Joseph W. Richards, Ph.D.

Professor of Metallurgy in Lehigh University; Professor of Electro-chemistry in the Franklin Institute; Secretary of the American Electrochemical Society.

PROBLEM 3.

An electric furnace is charged with Lake Superior hematite (90% Fe^2O^3, 10% SiO^2) mixed with pure SiO^2 sand, and with Anthracite coal (90% fixed carbon, 10% ash—which may be assumed SiO^2). The alloy produced is 50% Si and 50% Fe. The liquid alloy runs from the furnace at 1600° C., carrying 461.5 Calories per kg. The gases pass off at 500° C., and contain CO and CO^2 in the proportions of 1 to 2, by volume. One-fifth the energy of the current is lost by radiation from the furnace and conduction to the ground.

Required:—

(1) A heat balance sheet of the furnace, per metric ton of alloy produced.

(2) The electric energy necessary to produce a metric ton of alloy.

(3) The electric current required to produce one ton of alloy per hour.

Solution:—

(1) Oxygen given off by SiO^2 $500 \times {}^{32}/_{28} = 571$ kg.
" " " Fe^2O^3 $500 \times {}^{48}/_{112} = 214$ "

" " " Charges $= 785$ "

Ratio of CO to CO^2 by volume $= 2$
" " O to C in gases, by weight $= 1.75$
Fixed carbon required $= 785 \div 1.75 = 449$ kg.
Coal used $= 447 \div 0.9 = 499$ "
SiO^2 necessary in furnace $= 500 + 571 = 1071$ "
" in ash of coal $= 50$ "
" in ore used $= 714 \times {}^1/_9 = 79$ "
" sand necessary $= 1071 - (50 + 79) = 942$ "

HEAT DISTRIBUTION.

		Calories.
Heat in melted alloys		$= 481,500$
" hot gases, at 500°:		
CO 616 m³ × 240 =	147,840	
CO² 308 " × 156 =	48,050	
		$= 195,890$
Heat for reductions:		
SiO^2 500 × 7595 =	3,797,500	
Fe^2O^3 500 × 1746 =	873,000	
		$= 4,670,500$
Radiation and conduction		$= X$

Total heat requirement $= 5,347,890 + X$ Calories.

HEAT AVAILABLE.

Oxidation of C to CO^2	
$166.3 \times 8100 =$	$= 1,347,040$
Oxidation of C to CO	
$332.7 \times 2430 =$	$= 808,460$
Energy of electric current	$= 5X$

Total heat available $= 2,155,500 + 5X$ Cal.
Whence, equating these, $X = 793,100$ Cal.
and $5X = 3,965,500$ "

(2) The electric energy is obtained by noting that the kilowatt-hour represents 860 Calories, if entirely converted into heat energy. We therefore require, to produce one metric ton of alloy

$$3{,}965{,}500 \div 860 = 4{,}610 \text{ kilowatt-hours.}$$
$$= 0.526 \text{ kilowatt-year.}$$

(3) To produce one ton of alloy per hour would require current equal to 4,610 kilowatt capacity.

ENERGY REQUIRED FOR REDUCTION.

Two extremes are possible in the reduction of iron oxide: first, that only CO gas results; second, that equal volumes of CO^2 and CO result. This last proportion is only attained by having the maximum possible amount of reduction by CO gas. The chemical formulæ are:

$$Fe^2O^3 + 3\,C = 2\,Fe + 3\,CO.$$
$$Fe^2O^3 + 2\,C = 2\,Fe + CO + CO^2.$$

The relations are very simple. For 112 parts of iron set free and 48 parts of oxygen taken up by the carbon, there is required either 36 or 24 of carbon, and the heat generated by the oxidation of the carbon set free against the heat required to reduce the Fe^2O^3 is

Case 1:

Reduction of Fe^2O^3	= 195,600	Calories
Formation of 3 CO	= 87,480	"
Deficit	= 108,120	"

Case 2:

Reduction of Fe^2O^3	= 195,600	"
Formation of CO = 29,160		
" " CO^2 = 97,200		
	= 126,360	"
Deficit	= 69,240	"

Thus, although only two-thirds as much carbon is used in the second case as in the first, yet 44 per cent. more energy is gotten from it, and the deficit to be made up electrically is reduced 38,880 Calories.

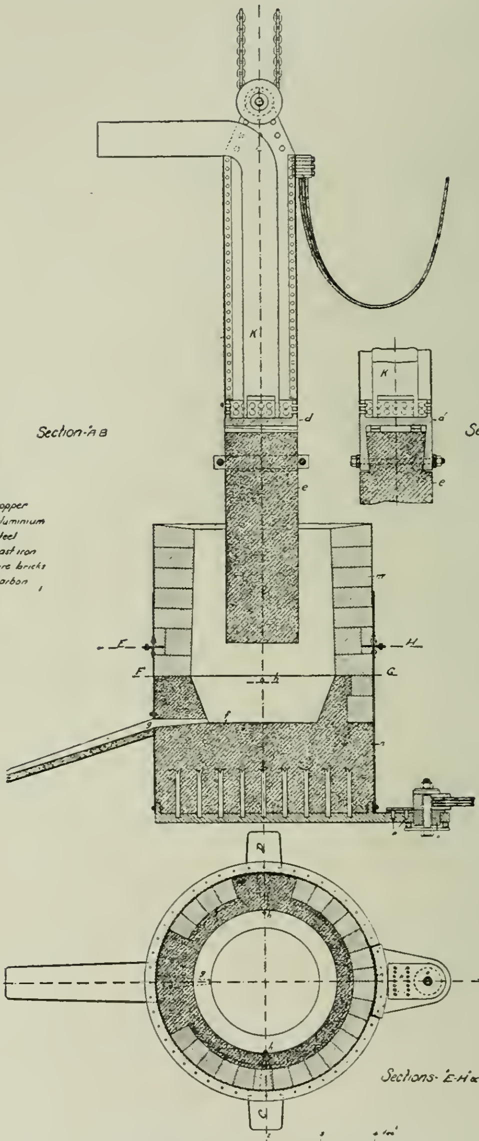


Fig. 12. Electrical furnace used at Sault Ste. mine for reducing iron ores to pig-iron.

If we assume that the product is pig-iron with 95 per cent. of iron, and 4 per cent. carbon, there will be a heat deficit per 100 kg. of pig iron of

$$108{,}120 \times \tfrac{95}{112} = 91{,}710 \text{ Calories in Case 1.}$$
$$69{,}240 \times \tfrac{95}{112} = 65{,}780 \quad \text{“} \quad \text{“} \quad \text{“} \quad 2.$$

and the fixed carbon in the reducing agent used must be

$$(36 \times \tfrac{95}{112}) + 4 = 34.5 \text{ kg. in Case 1.}$$
$$(24 \times \tfrac{95}{112}) + 4 = 24.4 \quad \text{“} \quad \text{“} \quad \text{“} \quad 2.$$

The amount of coke, charcoal or anthracite used must depend on its percentage of fixed carbon Thus, taking petroleum coke at 99 per cent. fixed carbon, coke 90 per cent., anthracite 95 per cent., charcoal 92 per cent., there would be required per 100 of pig-iron made:

	Petroleum Coke	*Anthracite*	*Charcoal*	*Coke*
Case 1............	34.9	36.3	37.5	38.3
Case 2............	24.7	25.7	26.5	27.1

The electric current must make up the deficit in the heat of the reduction, must supply all the sensible heat in the slag and pig-iron, decompose carbonate of lime used as flux, drive off moisture and volatile matter from charges, supply the sensible heat in the waste gases, and supply radiation and conduction losses.

Heat in Slag: This will vary with the weight of slag and its temperature at tapping. It will be not less than 400 Calories per kilogram, and may easily reach 600. The weight of slag per 100 kg. of iron will vary with the amount of gangue in the ore and the kind of slag made, *i. e.*, the amount of limestone added to flux it. This weight may be very variable, it may be from 15 kilos of slag from rich ore to as much as 100 for poor ore. This heat requirement must be worked out for each specific case.

Heat in Pig-Iron: This would scarcely ever be less than 300 Calories per unit, and might easily run up to 400.

Heat in Waste Gases: This depends on the amount and temperature. They may escape as hot as 1000° C., which would be very crude practice. They might be cooled to 100° C., which would be very good practice.

Heat to Evaporate Moisture: This is 606 Calories per unit of moisture evaporated. A preliminary drying is of advantage thermally, but a damp charge will form less dust.

Heat to Decompose Carbonates: This is 1026 Calories per unit of CO^2 driven off limestone; 846 from dolomite. It may amount to a large item if much raw flux is used.

Heat Conducted to the Ground: This will be very variable, according to the size of the furnace, and it may be 10,000 Calories per 100 kg. of iron produced, and in other cases two or three times that much.

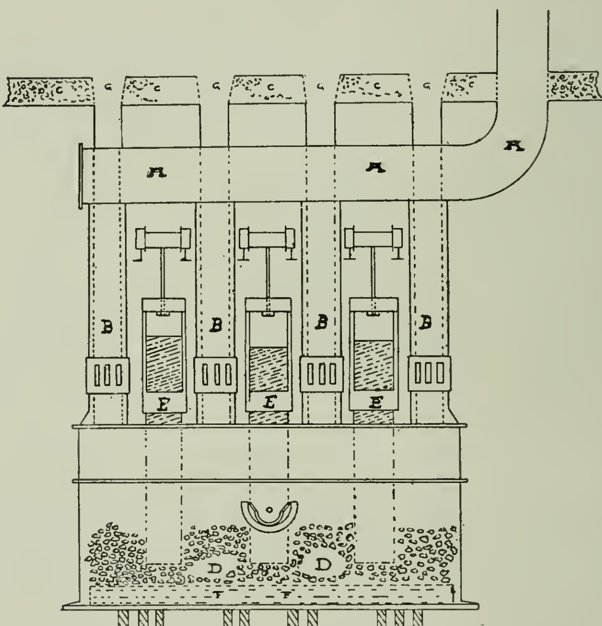


Fig. 13. A tri-phase electric furnace of 2000 H. P. used in Shasta, California, for the production of pig-iron.

Heat Conducted to the Air and Radiated: This may be as low as 10,000 Calories per 100 kg. of pig-iron, and again may be 50,000, in a small furnace poorly designed.

Reduction of Other Metallic Oxides: These may form an important part of the charge, and the heat required to reduce silicon, manganese, and phosphorous may be quite large; also the reduction of CaO to form CaS is not to be neglected on a high sulphur charge.

REDUCTION OF IRON ORES.

The Canadian Government appointed a commission in 1905 to report on the possibilities of the electrical production of pig-iron, and in 1906 gave it authority to supervise experiments to determine the feasibility of this matter as applied to Canadian ores. The experiments were carried out under the supervision of Drs. Haanel and Héroult, and were the subject of an elaborate report. Since the writer has gone into an extended discussion of these experiments and their teachings, in a paper read at the Twelfth General Meeting of the American Electrochemical Society, and to be published in Vol. XII of that Society's Transactions, the discussion will not be repeated here. Suffice it to say that several hundred tons of pig-iron were made from hematite and magnetite ores, in an electrical furnace of the type shown in elevation and plan in Fig. 13, showing the possibility of producing a ton of pig-iron by about 0.25 H.P. years of electrical energy, and demonstrating the commercial practicability of the operation in favorable localities. Later, Dr. Héroult has erected for Mr. Nobel, in Shasta County, California, a 2,000 H.P. tri-phase furnace, shown diagrammatically in Fig. 14, which started in operation July 4, 1907, and is in reality the pioneer electric pig-iron furnace of the commercial world. The whole subject is in an elementary, but nevertheless a very rapidly developing stage.

PROBLEM 4.

Assuming 100 kg. of an ore containing 9% Fe^2O^3 and 10 SiO^2, fluxed by addition of 18 $CaCO^3$ and reduced by 20 of petroleum coke. Pig-iron 95 Fe, 4 C, 1 Si.

Required: The probable electric energy requirement per metric ton (1000 kg.) of pig-iron made.

Solution:

Ore needed

$$950 \div (0.90 \times 0.7\ ) = 1508 \text{ kg.}$$

Oxygen from reduction

$$950 \times \tfrac{48}{112} = 407$$
$$10 \times \tfrac{32}{28} = \ \ 14$$
$$\overline{} \qquad 421 \text{ kg.}$$

Oxygen from $CaCO^3$

$1508 \times 0.18 \times {}^{16}/_{100} = 43$ "

Sum $= 464$ " $=$ O in gases.

Carbon from coke

$1508 \times 0.20 \times 0.99 = 299$ "

Carbon from flux

$1508 \times 0.18 \times 0.12 = 21$ "

Total C in furnace $= 320$ "

" C in pig-iron $= 40$ "

" C in gases 280 "

Gases formed

$280 \div 0.54 = 519$ m³ CO & CO^2

$= 126$ " CO^2

$= 393$ " CO

Heat of oxidation of carbon

CO $212 \times 2430 = 515,160$ Cal.

CO^2 $47 \times 8100 = 380,700$ "

895,860

Reduction of Fe: & Si:

$950 \times 1726 = 1,639,700$ "

$10 \times 7500 = 75,000$ "

1,714,700

Deficit, 818,840 Cal.

Decomposition of $CaCO^3$.

$56 \times 1026 = 57,450$ "

Heat in Slag:

$282 \times 500 = 141,000$ "

Heat in Pig-Iron:

$1000 \times 350 = 350,000$ "

Heat Conducted: $= 200,000$ "

Heat Radiated: $= 300,000$ "

Heat in Hot Gases at 500°:

CO^2 $126 \times 240 = 30,240$

CO $393 \times 155 = 61,915$ 92,150 "

Net Heat to be supplied: 1,959,440 "

Kilowatt-hours =

$$\frac{1,959,400}{860} = 2280 \text{ per ton of pig-iron.}$$

Kilowatt-years =

$$\frac{2280}{8760} = \mathit{0.26} \text{ k.w. year.}$$

REDUCTION OF IRON ORE.

This is really only a special case of the ferro-alloy practice, since if the other metallic oxides are left out we can get cast-iron, steel or pure iron, according to the excess of carbon used. Iron oxides are reduced in the blast furnace principally by CO gas formed by combustion before the tuyeres. The reaction usually lies between these two equations:

$$Fe^2O^3 + 9\,CO = 2\,Fe + 3\,CO^2 + 6\,CO.$$
$$Fe^2O^3 + 6\,CO = 2\,Fe + 3\,CO^2 + 3\,CO.$$

These reactions require either 9 C (108 parts) or 6 C (72 parts) to be burned at the tuyeres for every 2 Fe (112 parts) of iron produced. This means that the fuel used must be some 75 to 100 per cent. of the weight of the iron produced. Modern practice averages 100 per cent., more is commonly used in producing high silicon iron, and less is attained usually only with pure fuel and purer ores than the average.

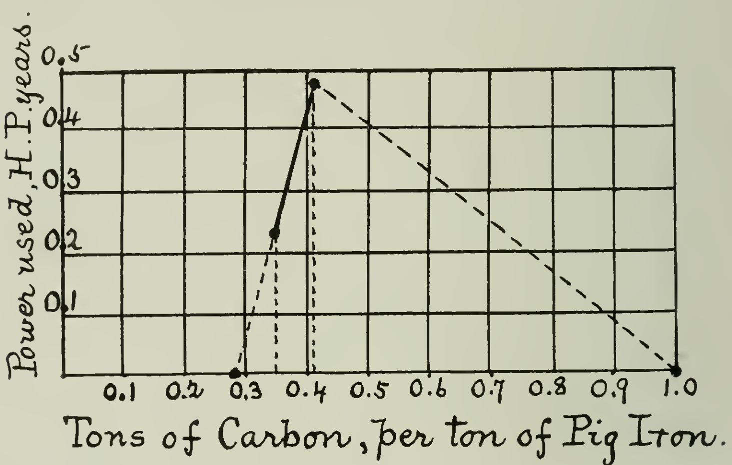
In the electric furnace there is no blast, and the 6 CO or 9 CO noted above as formed by combustion at the tuyeres can be assumed as formed by *reduction* of iron oxide at the hottest part of the furnace. The reaction would be:

$$3\,Fe^2O^3 + 9\,C = 6\,Fe + 9\,CO.$$
$$2\,Fe^2O^3 + 6\,C = 4\,Fe + 6\,CO.$$

This means that for a given weight of carbon used in the two furnaces, the electric furnace ought to turn out three to four times the weight of iron (8 Fe or 6 Fe instead of 2 Fe), or for a given weight of iron produced that only $\frac{1}{3}$ to $\frac{1}{4}$ as much carbon need be used, or say 25 to 35 per cent. of the weight of iron made. $\frac{1}{3}$ to $\frac{1}{4}$ of 75 to 100 per cent.

These figures are fully borne out in practice, in that experi-

ments have approximated these requirements. For instance, at Livet 0.34 tons of coke was used per ton of pig-iron produced, but considerable iron and manganese remained in the slag. In another experiment 0.41 tons was used, with still iron and manganese left in the slag. In the first case 0.226 electric horse-power years was used per ton of iron produced, in the second, 0.475. If we plot these figures we have



The dotted line at the right is hypothetical, but is intended to suggest the fact that about one ton of carbon per one ton of iron made is needed if no electrical power were used. The hypothetical dotted line to the left is simply an extension of the line giving the two points for which data were plotted. We see it striking the axis of abscissas at 0.28. This suggests very strongly the idea that 0.28 carbon per ton of pig-iron is the quantity which is to be approached as the efficiency of the furnace is increased. For instance, if the furnace could be run on 0.1 H.P. year, the carbon required would probably be simultaneously reduced to 0.30 ton per ton of pig-iron. This statement really puts the cart before the horse; it should properly read: if the furnace by proper design and running, was run with 0.30 ton of fuel for reduction per ton of pig-iron, the power consumption would probably be reduced to 0.10 H.P. year per ton of product.

These figures appear anomalous. It seems like saying—leave more for the electric current to do, and it takes less current to do

it. The explanation of the paradox is that in the first place, the electric current does not perform any reduction in either case or in any case. So that decreasing the carbon used does not put any more work of reduction on the current; and in the second case the carbon is burned in larger proportion to CO, thus giving not only more heat per unit of carbon but actually giving *more* heat from the smaller weight of carbon than was produced in the first case from the larger weight. By using less carbon (within limits, of course,) we actually get more heat generated by its oxidation, and therefore can get along with *less* electrical energy.

The point to be recognized and kept clearly in mind is that a given weight of iron reduced liberates a given weight of oxygen. We have approximately 0.4 ton of oxygen set free for a ton of pig-iron produced. If this burns carbon only to CO, it can burn 0.3 ton of carbon, and give off in doing it 729,000 Calories. If it burns carbon half to CO and half to CO^2, it can burn only 0,225 tons of carbon, but it will generate in doing it 972,000 Calories. If it could possibly burn carbon all to CO^2 (it cannot, as far as we know, under these circumstances) it could burn only 0.15 ton of carbon, but would generate thereby 1,215,000 Calories. We therefore reach the important conclusion, that the less carbon is used in the electric furnace reduction of iron ore the more heat will be generated by its combustion, and the less electric energy will be required; within the limits, of course, of using enough carbon to perform reduction.

The key-note to economy in electric furnace reduction of iron-ore is the reduction of the carbon in the charge to the lowest possible minimum. This will coincide with the largest possible production of CO^2 in the furnace gases, and the analysis of the escaping gases will give an exact criterion of the running of the furnace. It will also coincide with the minimum of electrical energy needed to run the furnace.

How can these conditions be attained? By studying the design of the furnace, and particularly the conditions favoring the reduction of iron oxide by CO gas, and formation of CO^2. These are: slow passage of gases through the charge; high column of charge; uniform but small size of the pieces of charge material; absence of dust or fines in the charge. Electro-metallurgical engineers should give their best attention to the study of these conditions and their accomplishment. If this is

coupled with a study of the best shape of the furnace, and the best means of reducing radiation and conduction losses, the minimum of carbon required, and of electrical energy necessary will be attained. These are considerably below what is now being reached in the crude, imperfect "first attempts" which are doing service at present—furnaces which are in point of technical development comparable to the Philippine Islands' crude blast furnace. They are no more like the electric furnace which is shortly to be, than the old charcoal furnace of Dud Dudley, which made fifteen tons of iron a week, is like a modern Edgar Thompson giant. But there will not be two centuries between, this time,—two decades will suffice.

ALUMINUM COATED CONDUCTOR PIPE, EAVES TROUGH, ETC.

Reeves Mfg. Company, Canal Dover, Ohio, is putting on the market a new line of aluminum coated conductor pipe, eaves trough, elbows and shoes, &c., which it declares to be rustproof, not affected by acid fumes and requiring no painting. It is also declared that the product will solder freely and will double seam without scaling. The company claims for these goods the rustproof qualities of aluminum and the wearing qualities of copper, although they cost about one-third as much as copper, and puts them out with the guarantee to replace them if they rust out at any time within twenty years.

THE approximate horsepower of gas engines may be calculated by empirical rules formulated by Dugald Clerk, the eminent British authority. He uses two rules, one for engines not exceeding twelve horsepower and the other for larger engines. In both formulas, D represents the diameter of the cylinder in inches, and N the number of cylinders. The mean effective pressure and the piston speed being about constant, are taken care of in the constants used in the expressions. For the smaller type the formula is

$$\text{Horsepower} + \frac{D^2 \times N,}{3}$$

while the larger type uses the same formula, but the constant becomes 2.4 instead of 3, as used in the denominator. The mean effective pressure in each case is assumed to be 70 lbs. per square inch, while the piston speed is 800 feet per minute for the smaller engine, and 1000 feet for the larger.—*Iron Age.*

Section of Photography and Microscopy.

(Stated meeting held Thursday, November 7, 1907.)

Radio-Active Minerals Found in Pennsylvania and Their Effect on the Photographic Plate.

By Edgar T. Wherry.

Of the many wonderful properties possessed by radio-active bodies, perhaps none is more striking and characteristic than the power of emitting rays, which, passing through even considerable thicknesses of opaque matter, will affect and leave a definite record of their existence upon a photographic plate. It was, indeed, through this property that the very existence of radio-activity was originally discovered, over ten years ago. Becquerel, it will be remembered, was following up the observation of Niewenglowski that calcium sulfide, in phosphorescing after exposure to sunlight, gave out radiations which acted upon a sensitive plate enclosed in thick black paper, and was repeating the experiment using uranium nitrate as the phosphorescent substance. By accident, the uranium salt was left upon the plate for some time, without having been exposed to the sun at all, and it produced an image just the same. From this small beginning, through the brilliant researches of the many able investigators who have applied themselves to the subject, the vast series of radio-active phenomena has been gradually unfolded to our view.

All of the artificial uranium salts having proved to be photographically active, experiments were next directed to natural compounds of the metal, and pitch-blende was found to yield a stronger effect than any substance previously known. The work

of the Curies upon this mineral, culminating in the separation of pure radium compounds, is now so familiar to everyone that it needs but passing mention. Pitch-blende, however, was by no means unique in its power of affecting the plate,—many other minerals were soon found to possess similar properties.

The most exhaustive of the early studies of this phase of the subject was undoubtedly that of Crookes who, in 1899-1900, went through every mineral in his cabinet—"a somewhat extensive collection, numbering many fine specimens"—and published a list of sixteen species which he found to be active.* Several other lists have since been published,† until now over a hundred minerals are known to yield photographic effects.

In the State of Pennsylvania, and especially in the southeastern portion, uranium-bearing minerals are by no means uncommon. At present writing some fifty localities are known from which nearly twenty different species have been obtained, and every now and then new finds are reported. These occurrences are confined almost exclusively to the areas of highly metamorphosed schist and gneiss of our region, being especially numerous where pegmatites are developed, as in southern Delaware County, although they are not infrequent in the City of Philadelphia itself. As the same minerals from other localities had been repeatedly observed to affect the plate, it occurred to the writer that it would be interesting to endeavor to obtain similar results with some of these local specimens, and accordingly the study about to be described was undertaken.

The early writers are strangely silent regarding the details of the methods they employed. Becquerel says simply,‡ "A Lumiere photographic plate—gelatino-bromide—is enveloped in two sheets of very thick black paper." Bardet§ also uses Lumiere plates and an "energetic developer, such as metaquinone and formosulfite." But not one of the many other contributors

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*Radio-activity of uranium. Proc. Roy. Soc., **66**, 1900, 409-423.

†The most complete is that of Pisani: Examen de plusiers minéraux au point de vue de leur radio-activité. Bull. Soc. Min., **27**, 1904, 58-63.

‡Sur les radiations émises par phosphorescence. Comptes Rendus **122**, 1896, 420.

§Essai de mesure de l'activité photographique de certains minéraux. Bull. Soc. Min., **27**, 1904, 63-66.

PLATE I.

(11) (8) (3. W.)

Figure 1. Radiographs from the most powerfully active minerals. Slightly reduced. Exposure 5 days. Note penetration of key at the right.

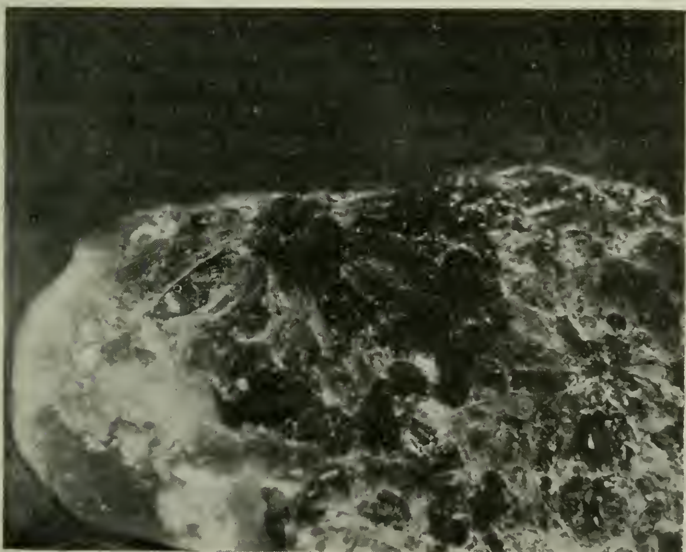

Figure 2. Natural Radiographs. [See page 74] Crystals of Cyrtolite from Morgan, Delaware county, surrounded by radiating cracks in the granular quartz rocks. Three times enlarged.

to the subject mentions the character of plate or developer used, leaving it to be supposed that, after all, variations in these would probably make no difference in the final result. Actual trial soon showed, however, that the kind of plate employed is, indeed, a very important matter. After experimenting rather extensively with the various grades on the market, Cramer's X-ray plates were finally selected as best suited to the purpose.

The method of protecting the plates with black paper, as used by most of the previous workers, was here adopted throughout. The alternative of placing the specimens directly on the plate and then enclosing the whole in a light-tight box did not appear expedient, for the possibility of injury to the sensitive film and of a direct chemical effect of the substances themselves would introduce a considerable element of uncertainty into the results. The black paper used consisted of the envelopes supplied with the X-ray plates, the manipulation of which is so obvious that it needs no special description.

In regard to the time of exposure it seemed wise to depart from the usual custom. When a mineral failed to produce an image after two or three days' exposure, it had ordinarily been considered inactive. But as it appeared probable that many of the specimens under investigation would contain only extremely minute traces of any active constituents, and as there could be no objection to longer exposure on theoretical grounds, the effect was tried of leaving them on the plates for several weeks. It was then found that if the X-ray plates were allowed to remain in the envelopes for much longer than a month they would gradually undergo a decomposition, so that when developed they would be evenly covered by a stain of metallic silver. Three weeks was finally chosen as the most suitable time of exposure for the weakly active minerals, for in that period most of them would show a distinct and definite result.

The development of the plates required less consideration, although here also the lack of published data made repeated trials necessary; the developer finally selected contained two parts of metol to one of hydrochinon, and was made about twice the usual strength. After remaining in this for about ten minutes, until the image began to fade away, the plates were fixed and finished as usual.

Details concerning the specimens used and the results obtained

are presented in tabular form on succeeding pages; but a brief discussion of the experiments will not be out of place here. The minerals studied may be divided into two groups, according to their uranium content. The first group includes those like uraninite, gummite, autunite, etc., which contain 50% or more of the metal. These showed, naturally, a very high degree of activity, and yielded distinct prints in one hour's exposure. In fact, in one trial a perceptible image was produced by the Avondale uraninite in fifteen minutes. Such prints, however, were too faint for reproduction, and those shown in the plates below represent exposures of five days. Figure 1, in plate 1, was made with the three most active specimens, using iron keys about one millimeter thick. The penetrating power of the "rays" is clearly visible in the picture at the right, the position of each fragment of uraninite along the shaft of the key being indicated by a bright spot.

Besides these uranium compounds, every mineral known to contain columbium, the rare earths, zirconium, titanium or tungsten was tested by a three weeks' exposure. The columbates all proved to be active, though mostly only faintly so. The euxenite from Morton gave, to be sure, a very strong print, but probably contains 10% or more of uranium. In this connection it is interesting to note that the columbite from Mineral Hill, containing, according to Genth's analysis, .18% of uranium oxide, is much less active than specimens of the same mineral found at Morton and at Broad and Olney Avenue, Philadelphia. Unfortunately, quantities of these latter two sufficient for analysis have never been found, but it is possible that their uranium content is greater.

Of the rare earth minerals, monazite showed considerable activity, but then it almost certainly contains thorium and possibly uranium also. Allanite usually yielded a distinct print, but this is also probably to be ascribed to the presence of thorium. Lanthanite gave a negative result. Zircons were in most cases faintly but distinctly active, the variety cyrtolite (which may contain thorium and uranium) yielding the strongest effects.

Although many specimens of rutile—titanium dioxide—were examined, not one of them gave the slightest indication of activity. Titanite was also inactive in all but one or two cases. On account of the similarity of tungsten to uranium a specimen

PLATE II.

(3 V.) Uraninite. Avondale A.
(5 days)

(8) Gummite. Avondale A.
(5 days)

(12) Uranochre.
Avondale A.

(16) Randite.
Frankford A.

These and all that follow, were exposed 3 weeks.

PLATE III.

(17) Autunite.
Mt. Airy.

(34) Torbernite.
Leiperville.

(37) Columbite.
Morton.

(44) Euxenite.
Morton.

of scheelite from Frankford was tried, but it gave no effect whatever. The radio-activity of potassium, recently observed by Campbell and Wood,* has not been confirmed, for orthoclase, though frequently appearing as the gangue of very active minerals, has never produced the slightest print. Typical prints of these various minerals are shown in the plates.

It is to be concluded, then, from these experiments that uranium and thorium must be present in order that a mineral should show photographic activity. Whether produced by these metals themselves or by some associated substance, such as radium, there is no evidence to decide. The object of this communication will be attained if it shall have been demonstrated, beyond all question, that many minerals found in the State of Pennsylvania possess definite radio-active properties.

NOTES ON THE TABLE.

The accompanying table contains not only all of the minerals which have given definite proof of their radio-activity, but also those which, although specimens for experiment could not be obtained, might reasonably be expected to show analogous properties.

The identification of the minerals used has been in some cases rather uncertain on account of the small amount of material obtainable. Several of the names assigned are therefore to be regarded as provisional only, and are so indicated by interrogation marks (?). These are as follows:

9-15. *Uranochre.* Under this heading are included several yellow uranium compounds appearing as more or less amorphous or pulverulent coatings. Most of them are probably silicates (uranophane), but some may be sulphates (uraconite).

46. *Fergusonite.* Not seen.

47. *Microlite.* Minute brown grains closely resembling the Virginia microlite.

48. *Samarskite.* Small grains with the brilliant sub-metallic luster of this mineral.

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*Radio-activity of the alkali metals. Proc. Cambridge Philosophical Society, 14, 1906, 15-21.

PLATE IV.

(54) Allanite. East Bradford.

(61) Monazite.
Boothwyn.

(86) (87)

Cyrtolite. Boothwyn.
(86) 12 brown crystals.
(87) 6 yellow crystals.

Tabular List of Radioactive Minerals Found in Pennsylvania.

No.	Species	Principal Constituents	Minor Constituents	Locality
1	Uraninite	U.	Pb, Ba, Ra.	Fairmount
2	"	"	"	Swarthmore
3	"	"	"	Avondale A
4	"	"	"	Chester
5	Gummite	"	Pb, Ca, H_2O	Mt. Airy
6	"	"	"	Llanerch
7	"	"	"	Swarthmore
8	"	"	"	Avondale A
9	Uranochre ?	"	H_2O	Mt. Airy
10	"	"	"	Broad & Olney
11	"	"	"	Fairmount
12	"	"	"	Avondale A
13	"	"	"	Leiperville
14	"	"	"	Chester
15	"	"	"	Mauch Chunk
16	Randite	U, Ca, C.	———	Frankford A
17	Autunite	U, Ca, P.	———	Mt. Airy
18	"	"	———	Broad & Olney
19	"	"	———	Girard Ave
20	"	"	———	Fairmount
21	"	"	———	Llanerch
22	"	"	———	Avondale A
23	"	"	———	Leiperville
24	"	"	———	Upland
25	"	"	———	Chester
26	"	"	———	Mauch Chunk
27	Torbernite	U, Cu, P	———	Mt. Airy
28	"	"	———	Mermaid
29	"	"	———	Wingohocking
30	"	"	———	Fairmount A
31	"	"	———	Fairmount B
32	"	"	———	Jenkintown
33	"	"	———	Avondale A
34	"	"	———	Leiperville
35	"	"	———	Chester

No.	Discovered By	Date	Reference	Source	Descript'n	Intensity
1	Prof. A. P. Brown	——	Priv. Com.	—	———	—
2	W. (the writer)	1906	Min. Coll., *13*, 173	W	Small grains	A
3	T. D. Rand	(1892)	P.A.N.S., *1892*, 194	V, W	Fine cubic xls	A
4	T. D. Rand	(1874)	Min. Penna., 43	—	———	—
5	W.	1907	———	W	Minute speck	C
6	Mr. E. S. Law	1905	Min. Coll., *12*, 92	—	———	—
7	W.	1906	Min. Coll., *13*, 162	W	Thin coating	B
8	Prof. A. P. Brown	——	Priv. Com.	U	Large mass	A
9	W.	1907	———	W	Thin coating	B
10	Dr. Charles Travis	1905	Priv. Com.	W	Thin coating	B
11	T. D. Rand	(1892)	P.A.N.S., *1892*, 176	R	Small mass	B
12	T. D. Rand	(1892)	P.A.N.S., *1892*, 194	R	Coating	B
13	T. D. Rand	(1892)	P.A.N.S., *1892*, 193	—	———	—
14	(F. A. Genth)	(1874)	Min. Penna., 152	—	———	—
15	Mr. T. J. Lewis	——	Priv. Com.	W	Thin coating	B
16	T. D. Rand	1878	P.A.N.S., *1878*, 408	R	Coating	B
17	Mr. H. Miller	1907	Priv. Com.	W	Cryst. scales	B
18	Dr. Charles Travis	1905	Priv. Com.	W	Cryst. scales	B
19	Mr. E. A. Groth	(1902)	Min. Coll., *9*, 169	—	———	—
20	(J. D. Dana)	(1854)	Syst. Min., *4*, 430	A	Cryst. scales	B
21	Mr. E. S. Law	1905	Min. Coll., *12*, 92	—	———	—
22	T. D. Rand	——	———	R	Cryst. scales	B
23	T. D. Rand	(1874)	Min. Penna., 144	U	"	B
24	T. D. Rand	(1874)	Min. Penna., 144	R	"	B
25	T. D. Rand	——	———	R	"	B
26	(F. A. Genth)	(1874)	Min. Penna., 144	R	"	C
27	Mr. W. H. Tomlinson	1901	Min. Coll., *8*, 144	W	"	B
28	W.	1907	———	W	"	B
29	Mr. S. MacFeeters	——	Priv. Com.	—	———	—
30	T. D. Rand	(1868)	Syst. Min., *5*, 780	R	Cryst. scales	B
31	T. D. Rand	——	———	A	"	B
32	E. D. Drown	1892	P.A.N.S., *1892*, 182	R	Traces	D
33	T. D. Rand	——	———	U	Cryst. scales	B
34	T. D. Rand	(1874)	Min. Penna., 144	U	"	B
35	T. D. Rand	——	———	R	"	C

No.	Species	Principal Constituents	Minor Constituents	Locality
36	Columbite	Cb, Ta, Fe, Mn.	U.?	Broad & Olney
37	"	"	"	Morton
38	"	"	"	Avondale B
39	"	"	"	Mineral Hill A
40	"	"	"	Black Horse
41	"	"	"	A. Smedley's
42	"	"	"	Boothwyn
43	"	"	"	Landenberg
44	Euxenite	Cb, Ta, Ti, Y, U.	——	Morton
45	"	"	——	Delaware Co.
46	Fergusonite?	Cb, Ta, Y, Ce, U.	——	A. Smedley's
47	Microlite?	Cb, Ta, Ca, U.	——	Mineral Hill A
48	Samarskite?	Cb, Ta, Ce, Y, U.	——	Mineral Hill B
49	Allanite	Ce, Ca, Al, Fe, Si.	Th.	Mount Airy
50	"	"	"	Rittenhouse
51	"	"	"	Frankford B
52	"	"	"	Morton
53	"	"	"	Lenni
54	"	"	"	E. Bradford A
55	"	"	"	Pughtown
56	"	"	"	Bethlehem
57	"	"	"	Easton A
58	"	"	"	Lehigh Mt.
59	"	"	"	Pricetown
60	Monazite	Ce. P.	Th.	Morgan
61	"	"	"	Boothwyn
62	Zircon	Zr. Si.	Th.?	Neshaminy
63	"	"	"	Scottsville
64	"	"	"	Vanartsdalen's
65	"	"	"	Rocksville
66	"	"	"	Willow Grove
67	"	"	"	Dismal Run
68	"	"	"	Blue Hill
69	"	"	"	Brandywine S.

No.	Discovered By	Date	Reference	Source	Description	Intensity
36	W.	1904	Min. Coll., *14*, 42	W	Small xls	C
37	W.	19 6	Min. Coll., *13*, 162	W	Grains	B
38	Mr. E. S. Law	1906	Min. Coll., *13*, 79	L	Crystal	C
39	(H. C. Lewis)	1882	P.A.N.S., *1882*, 51	R	"	D
40	J. T. M. Cardeza	(1892)	P.A N.S., *1892*, 200	—	——	—
41	J. T. M. Cardeza	(1892)	P.A.N.S , *1892*, 200	—	——	—
42	J. T. M. Cardeza	——	——	R	Crystals	D
43	Samuel Tyson	1850	Min. Penna., 137	—	——	—
44	Mr. E. S. Law	1905	Min. Coll., *14*, 33	L	Crystals	B
45	Mr. John Eyerman	——	Priv. Com.	—	——	—
46	J. T. M. Cardeza	(1892)	P.A.N.S., *1892*, 200	—	——	—
47	W.	1907	——	W	Minute grains	B
48	W.	1907	——	W	"	B
49	W.	1907	——	W	"	?
50	Mr. S. H. Hamilton	——	Priv. Com.	—	——	—
51	W.	1906	Min. Coll., *13*, 63	W	Cryst. masses	D
52	W.	1906	Min. Coll., *13*, 173	W	"	C
53	Mr. H. C. Borden	——	Priv. Com.	—	——	—
54	W. W. Jefferis	(1850)	Syst. Min., *3*, 356	U	Lumps	D
55	(J. D. Dana)	(1892)	Syst. Min , *6*, 1067	—	——	—
56	(J. D Dana)	(1868)	Syst. Min., *5*, 289	A	Rough xls	D
57	(J. D. Dana)	(1868)	Syst. Min., *5*, 289	—	——	—
58	(F. A. Genth)	1874	Min. Penna., 80	—	——	—
59	(J. D. Dana)	(1868)	Syst. Min., *5*, 289	R	Lumps	?
60	Mr. J. G. Dailey	1899	P.A.N.S., *1899*, 377	R	Small xl	C
61	W.	1906	Min. Coll., *14*, 45	W	Crystals	B
62	Mr. J. F. Vanartsdalen	——	Priv. Com.	W	"	?
63	Mr. J. F. Vanartsdalen	——	Priv. Com.	—	——	—
64	Edward Swift	1829	J.A.N.S., *6*, (1) 48	R	Crystals	D
65	W.	1903	Min. Coll., *13*, 22	W	"	D
66	Isaac Lea	(1821)	J.A.N.S., *1*, (2) 470	—	——	—
67	(F. A. Genth)	(1874)	Min. Penna., 77	—	——	—
68	(F. A. Genth)	(1874)	Min. Penna., 77	—	——	—
69	(J. D. Dana)	(1850)	Syst. Min., *3*, 655	—	——	—

No.	Species	Principal Constituents	Minor Constituents	Locality
70	Zircon	Zr. Si.	Th. ?	E. Bradford B
71	"	"	"	Copesville
72	"	"	"	E Marlboro
73	"	"	"	Pughtown
74	"	"	"	Springton
75	"	"	"	Chester Springs
76	"	"	"	Coventryville
77	"	"	"	Easton B
78	"	"	"	Bethlehem
79	"	"	"	Hellertown
80	"	"	"	Pricetown
81	Cyrtolite ?	"	Ce, U, Th.	Mermaid
82	"	"	"	Broad & Olney
83	"	"	"	Morton
84	"	"	"	Avondale A
85	"	"	"	Morgan
86	" brown	"	"	Boothwyn
87	" yellow	"	"	Boothwyn
88	Massicot ?	Pb.	U. ?	Morton
89	Uran-Hyalite	Si.	U.	Frankford A
90	"	Si.	U.	Fairmount A
91	Titanite	Ti, Si, Ca.	Th.	Canal Road
92	"	"	"	Morton
93	"	"	"	Chadd's Ford

ABBREVIATIONS.

Reference Column.

Priv. Com.—Private Communication.

A. J. S.—American Journal of Science, New Haven.

J. A. N. S.—Journal of the Academy of Natural Sciences of Philadelphia, 1st series.

Min. Coll.—Mineral Collector, New York.

Min. Penna.—A preliminary report on the mineralogy of Pennsylvania, by Frederick A. Genth; Report B, Second Geological Survey of Pennsylvania, Harrisburg, 1874-1875.

P. A. N. S.—Proceedings of the Academy of Natural Sciences of Philad'a.

Syst. Min.—A System of Mineralogy, by James D. Dana, six editions, New York, 1837, 1844, 1850, 1854, 1868, 1892.

No.	Discovered By	Date	Reference	Source	Description	Intensity
70	Isaac Lea	1818	J.A N.S., *1*, (2) 470	—	———	—
71	(J. D. Dana)	1868	Syst. Min., *5*, 777	—	———	—
72	G. W. Carpenter	1826	A.J.S., (1) *10*, 221	A	Crystals	D
73	(J. D. Dana)	(1850)	Syst. Min., *3*, 654	—	———	—
74	Mr. F. J. Keeley	1905	Priv. Com.	—	———	—
75	(J. D. Dana)	(1850)	Syst. Min., *3*, 654	A	Crystals	?
76	(J. D. Dana)	(1850)	Syst. Min., *3*, 654	—	———	—
77	J. Finch	1824	A.J.S., (1) *8*, 239	—	———	—
78	(J. D. Dana)	(1868)	Syst. Min., *5*, 779	A	Crystals	?
79	(F. A. Genth)	(1874)	Min. Penna., 76	—	———	—
80	(J. D. Dana)	(1868)	Syst. Min., *5*, 275	A	Crystals	?
81	W.	1907	———	W	Rough xl	B
82	W.	1905	———	W	Minute xls	C
83	W.	1907	———	W	"	C
84	W.	1904	———	W	"	C
85	Mr. W. H. Tomlinson	1898	Min. Coll., *5*, 177	W	"	C
86	W.	1906	Min. Coll., *14*, 13	W	"	C
87	W.	1906	———	W	"	C
88	Mr. E. S. Law	1905	Min. Coll., *12*, 68	W	Minute grains	D
89	T. D. Rand	(1874)	Min. Penna., 61	R	Coating	D
90	T. D. Rand	(1892)	P A.N.S., *1892*, 176	A	"	D
91	L. Vanuxem	1818	J.A.N.S., *1*, (2) 469	A	Crystals	D
92	W.	1906	Min. Coll., *13*, 155	W	"	D
93	G. W. Carpenter	1826	A.J S., (1) *10*, 220	R	"	D

ABBREVIATIONS—(Continued).

Source Column. The collections of:
A.—The Academy of Natural Sciences.
L.—Mr. E. Stanley Law.
R.—Theodore D. Rand (Bryn Mawr College).
U.—The University of Pennsylvania.
V.—Mr. George Vaux, Jr.
W.—The writer.

Character Column.
Xls.—Crystals.
Cryst.—Crystalline.

Intensity Column.
A.—Very strongly active; good print in five days.
B.—Moderately active; strong print in three weeks.
C.—Feebly active; fair print in three weeks.
D.—Faintly active; barely discernible print in three weeks.
?.—No print in three weeks.

81-87. *Cyrtolite.* A series of more or less tetragonal looking minerals, varying from yellow to black in color. Form a second order prism with first order pyramid, usually simulating a rhombic dodecahedron; faces often very unequally developed, and occasionally curved. Frequently surrounded by radiating cracks in the rock, identical with the "stars" described by Hidden,* but rarely more than a centimeter across. These "stars" are apparently to be regarded as natural radiographs, for they can only have been produced by the influence of the radiations emitted by the crystals in determining the direction of the cracks developing in the granular quartz matrix while in process of solidification. They are sometimes found around other active minerals, but never around inactive ones. A photograph of a specimen of cyrtolite, recently found at Morgan, Delaware County, by Mr. E. S. Law, is shown at Figure 2, plate 1.

88. *Massicot.* A greenish gray earthy material which gives before the blowpipe reactions for lead, but in which no other elements could be detected with certainty.

The following arrangement is adopted:

Uranium oxides
carbonates
phosphates
Columbates
Rare earth silicates
phosphates
Zirconium silicates
Miscellaneous.

The constituents given are of course understood to be present in the form of oxides. They represent only the usual composition of the respective minerals, for, with one or two exceptions, the material here used has never been analyzed.

The localities are necessarily stated only briefly in the table and in order to describe them more fully, a check list is appended. Their arrangement is geographical, rather than geological.

The original discoverer of each occurrence is given as far as practicable; in the cases where no such information is at hand,

*Some results of late mineral research in Llano County, Texas. Amer. Jour. Sci., (4), 19, 1905, 425-433.

the name of the person who first announced it is introduced, in parenthesis, instead. The same applies to the year in which the material was first found.

In the reference column is given the place where notice of each occurrence was first published. When no reference is stated, it is understood that the material is preserved in the collection of the discoverer, but has never been announced or described. A list of the abbreviations used in this column is added below.

The collections from which the specimens tried were obtained are indicated in the column headed source by letters explained in the list of abbreviations. The writer embraces this opportunity to thank those in charge of the various collections for permission to make use of specimens and for assistance in carrying out the experiments.

The intensity given is not to be regarded as exact, for the results are not directly comparable on account of the uncertainty introduced by the varying character of the specimens. At least four different degrees can, however, be distinctly recognized, and they are described by appropriate letters.

CHECK LIST OF LOCALITIES.

Philadelphia County.

NORTHWEST SECTION.

Mt. Airy: McCrea's Quarry, at corner of Mermaid and Germantown Avenues.

Gummite ?	Torbernite
Uranochre ?	Allanite ?
Autunite	

Mermaid: Comly's Quarry, one-eighth mile southeast of Mermaid Station, P. & R. Ry.

Torbernite	Cyrtolite ?

Wingohocking: Quarries east of Wingohocking Station, P. & R. Ry.

Torbernite

Rittenhouse: The Rittenhouse Quarry, on Rittenhouse Lane, west of Wissahickon Avenue.

Allanite ?

Broad and Olney: Exposures at southeast corner of Broad Street and Olney Avenue. (Now walled up.)

Uranochre ?	Columbite
Autunite	Cyrtolite ?

NORTHEAST SECTION.

Frankford A.: The Frankford Quarry, at Leiper and Church Streets. (Abandoned.)

Randite	Uran-Hyalite

Frankford B.: Hoffman's Quarry, Fisher's Lane and Tacony Creek.
Allanite (Scheelite)

WESTERN SECTION.

Canal Road: "Quarry at the end of the Canal Road on the Schuylkill River." (Inaccessible.)
Titanite

Girard Avenue: Exposures on West River Drive, north of Girard Avenue Bridge.
Autunite

Fairmount A.: Quarry on Schuylkill River, opposite Fairmount Water Works. (Inaccessible.)
Uraninite Torbernite
Uranochre ? Uran-Hyalite
Autunite

Fairmount B.: Excavations and quarries for Penna. R. R. yards, just west of Fairmount A.
Autunite Torbernite

Bucks County.

Neshaminy: Exposures on Neshaminy Creek one-half mile northeast of Neshaminy Falls Station, P. & R. Ry., Southampton Township.
Zircon

Scottsville: Roadside exposures northwest of Scottsville, Southampton Township.
Zircon

Vanartsdalens: Vanartsdalen's limestone quarry, two miles north of Neshaminy Falls Station, P. & R. Ry., Southampton Township.
Zircon

Rocksville: Finney's Quarry, on Mill Creek, east of Rocksville, Northampton Township.
Zircon

Montgomery County.

Jenkintown: Heacock's Quarry, in Wyncote, one-quarter mile west of Jenkintown Station, P. & R. Ry., Cheltenham Township. Abandoned.
Torbernite

Willow Grove: Exposures along Old York Road, above Willow Grove, Moreland Township.
Zircon

Delaware County.

Llanerch: Cut on P. & W. Ry., one mile northeast of Llanerch, Haverford Township.
Gummite Autunite

Morton: Johnson's Quarry, three-quarters mile northwest of Morton Station, P., B. & W. R. R., Springfield Township.
Columbite Cyrtolite ?
Euxenite Massicot ?
Allanite Titanite

Swarthmore: Exposures along Crum Creek, one-half mile northwest of Swarthmore, Springfield Township.
Uraninite Gummite

Avondale A.: Leiper's Quarry, on Crum Creek, at Avondale, Springfield Township.

Uraninite	Autunite
Gummite	Torbernite
Uranochre?	Cyrtolite ?

Avondale B.: Quarry on west side of Crum Creek, south of Avondale A., Ridley Township.

Columbite

Leiperville: Deshong's Quarries, on the B. & O. R. R., west of Leiperville, Ridley Township.

Uranochre ?	Torbernite
Autunite	

Chester: "Near Chester."

Uraninite	Autunite
Uranochre ?	Torbernite

Upland: Samuel Crozer's Quarry, south of Upland, Chester Township.

Autunite

Blue Hill: Exposures west of Blue Hill, Upper Providence Township.

Zircon

Dismal Run: Painter's farm, on Dismal Run, one mile north of Lima. Middletown Township.

Zircon

Mineral Hill A.: Exposures north of Crump's serpentine quarry, one mile west of Media, Middletown Township.

Columbite	Microlite ?

Mineral Hill B.: Exposures west of Crump's Quarry, Middletown Township.

Samarskite ?

Black Horse: John Smith's farm, one-half mile east of Black Horse, Middletown Township.

Columbite

A. Smedley's: "On A. Smedley's farm," Middletown Township.

Columbite	Fergusonite ?

Lenni: Quarry on P., B. & W. R. R., west of Lenni Station, Middletown Township.

Allanite

Morgan: Quarries and exposures on Chester Creek Branch P., B. & W. R. R., south of Morgan Station, Aston Township.

Monazite	Cyrtolite ?

Boothwyn: Quarry south of B. & O. R. R., one-half mile southwest of Boothwyn Station, Upper Chichester Township.

Columbite	Cyrtolite, brown, prismatic
Monazite	Cyrtolite, yellow, "dodecahedral"

Brandywine Summit: Bullock's Quarry, one mile southwest of Brandywine Summit, Birmingham Township.

Zircon

Chester County.

East Bradford A.: Amos Davis's farm, one mile southwest of West Chester, East Bradford Township.

Allanite

East Bradford B.: "Two miles west of West Chester."
Zircon

Copesville: "Exposures near the Paper Mill, on the Brandywine, one mile south of Copesville," East Bradford Township.
Zircon

Chadd's Ford: Quarry west of Brandywine Creek, two miles northwest of Chadd's Ford, Pennsbury Township.
Titanite

East Marlborough: "Near Pusey's Saw Mill." East Marlborough Township.
Zircon

Landenberg: Nevin's Quarry, southwest of Landenberg, London Britain Township.
Columbite

Springton: Exposures near Springton School House, Wallace Township.
Zircon

Chester Springs: In the iron mines near Chester Springs and Yellow Springs, West Pikeland Township.
Zircon

Coventryville: Christman's Quarry, one-half mile south of Coventryville, South Coventry Township.
Zircon

Pughtown: Exposures south of Pughtown, South Coventry Township.
Allanite Zircon

Northampton County.

Easton A.: In the South Mountain, west of Easton.
Allanite

Easton B.: Quarries on Chestnut Hill, north of Easton.
Zircon

Bethlehem: In the South Mountains, three-quarters mile from Bethlehem.
Allanite

Lehigh Mountain: "Just south of Lehigh University."
Allanite

Hellertown: "In the South Mountains, one mile east of Hellertown."
Zircon

Berks County.

Pricetown: At Eckhardt's Furnace, and on several farms near Pricetown, ten miles northeast of Reading.
Allanite Zircon

Carbon County.

Mauch Chunk.
Uranochre ? Autunite

Sections.

(Abstract of Proceedings of Stated Meetings.)

MECHANICAL AND ENGINEERING SECTION.—Stated meeting held Thursday, November 27, at 8 P.M. President Charles Day in the chair. Present 125 members and visitors.

The paper of the evening was read by Mr. Richard L. Humphrey, on "The Work of the Structural Materials Laboratories."

The paper is reserved for publication in the *Journal.*

FRANCIS HEAD, *Sec'y.*

ELECTRICAL SECTION.—Stated meeting held Thursday, December 5, 8 P.M. Mr. Thomas Spencer in the chair. Present, eighty-two members and visitors. Mr. Edward R. Taylor, of Penn Yan, N. Y., read the paper of the evening on "The Method and Apparatus for the Manufacture of Carbon Di-Sulphide by the Electro-thermic Process." The paper was fully discussed and was referred to the Committee on Publication. The speaker received a vote of thanks for his interesting communication.

RICHARD L. BINDER, *Sec'y.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—Stated meeting held Thursday, December 12, at 8 P.M. Dr. Wahl in the chair. Present, 149 members and visitors. Dr. ——— Baer presented an interesting account of the methods adopted and practiced for the production of moving pictures, and illustrated his theme by the exhibition of a number of characteristic moving pictures.

The thanks of the meeting were tendered to the speaker of the evening.

Adjourned.

M. I. WILBERT, *Sec'y.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, December 18th, 1907.)

HALL OF THE INSTITUTE,
Philadelphia, Dec. 18, 1907.

President WALTON CLARK in the chair.

Present 146 members and visitors.

Additions to membership since last report, five.

The following nominations for officers, managers and committeemen to be voted for at the Annual Election to be held on Wednesday, January 15, 1908, were made:

For President,	(to serve one year).............	WALTON CLARK.
" *Vice-President,*	(" three years)...........	WASHINGTON JONES.
" *Treasurer,*	(" one year).............	CYRUS BORGNER.
" *Secretary,*	(" one year).............	WILLIAM H. WAHL.
" *Auditor,*	(" three years)...........	WILLIAM H. GREENE.

For Managers (to serve three years).

James Christie, John Birkinbine, Thomas P. Conard, Walton Forstall, Louis E. Levy, Richard Waln Meirs, Isaac Norris, Jr., Coleman Sellers, Jr.

(To serve two years.)
Chas. E. Ronaldson.

For the Committee on the Science and the Arts (to serve three years).

A. W. Allen, Carl G. Barth, Hugo Bilgram, Frank P. Brown, Kern Dodge, W. C. L. Eglin, J. Logan Fitts, Edward Goldsmith, Caspar Wistar Haines, Clarence A. Hall, Lewis M. Haupt, Robert Job, G. H. Meeker, Lucien E. Picolet, James S. Rogers, E. Alex. Scott, Harrison Souder, Martin I. Wilbert, Richard Zeckwer, Chas. J. Zentmayer.

(To serve two years.)
Eugene S. Powers.

The business of the evening was devoted to a series of informal communications on "Ærial Navigation." Mr. W. N. Jennings opened the subject by exhibiting a most interesting series of pictures taken during a number of balloon trips.

Dr. T. Chalmers Fulton, President of the Ben. Franklin Æronautical Society, followed with some remarks on the subject of "The Air: the Future Highway of Traffic and Transit."

Mr. Arthur T. Atherholt gave an interesting account of "A Balloon Trip from St. Louis to Canada."

This subject was closed by some highly interesting remarks by Prof. Samuel A. King, the veteran æronaut of Philadelphia, on "The Pleasures of Ballooning."

The President extended the thanks of the meeting to the speakers.

On Dr. Edward Goldsmith's motion, numerously seconded, the following preamble and resolutions were unanimously adopted:

"Whereas, The Franklin Institute has learned with much gratification of the contribution by Mrs. Anna Weightman Walker of Fifty Thousand Dollars to the Building Fund of the Institute; therefore

Resolved, That the grateful thanks of the Institute are due and are hereby tendered to the donor for this generous gift;

Resolved, That the gift be applied in some manner, which shall be acceptable to the donor, to establish, in connection with the new building of th Institute, a memorial of the late William Weightman."

Adjourned.

Wm. H. Wahl, *Secretary*.

JOURNAL

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FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA

FOR THE PROMOTION OF THE MECHANIC ARTS

VOL. CLXV, No. 2 83RD YEAR FEBRUARY, 1908

THE FRANKLIN INSTITUTE.

(Annual meeting held Wednesday, January 15, 1908.)

History of the Reaction Breakwater at Aransas Pass, Texas.*

BY LEWIS M. HAUPT, C.E., A.M., Sc.D.

Prof. of Civil Engineering, Franklin Institute, Philadelphia.

Publicity and Patriotism are the Bulwarks of a Republic.

Conservatism is not always the handmaiden of Progress as may be seen from the opposition which has attended the efforts to introduce an economic agency into the service for the utilization of natural forces for the improvement of commercial channels.

Early in 1887, the writer, under a *nom de plume,* submitted to the American Philosophical Society a thesis, entitled *"Physical Phenomena of Harbor Entrances,"* to secure a disinterested analysis of its merits, by experts, and nine months later, or on the 16th, of December, the Society awarded to its author the highly prized "Magellanic Premium for his Discovery in Physical Hydrography and his Invention of a System of Harbor Improvements." Immediately thereafter the plans were presented to the United

*Read by title.

States Board of Engineers, which filed a report in the War Department, dated March 16th, 1888, concluding in these words:

"The views are purely theoretical, are unconfirmed by experience and contain nothing not already well known, and which has a useful application in the improvement of our harbors."

No copy of this report, so adverse to the findings of the Philosophical Society, was sent to it or to the author, but was accidentally discovered some months later when a communication was mailed to the Chief of Engineers requesting permission to establish the truth of the so-called "theory," and asking for the citation of a precedent, in these words:

Gen'l Jas. C. Duane, Chief of Engineers.

June 30, 1888.

Dear General:—

I have the honor to forward herein a copy of my Reply to the Report of the Board of Engineers. . . . Since I believe the plans to be new, and hence unprecedented, it would doubtless be satisfactory to the Board, as well as to myself, if an opportunity were given me, to make a test, or to be referred to a similar construction which has failed. If there be none, it would be a valuable contribution to the profession to have a record of the facts from experience. I have therefore the honor to request that you will recommend, with the approval of the Board, if you so desire, that a trial be made, at a site to be agreed upon by the parties interested, in securing deep water."

On September 14, a letter was mailed to his successor, General Casey, making a similar request, and copies of the "Reply" were sent to all the members of the Board, but none of these communications elicited an acknowledgment.

This heritage of prejudged condemnation and opposition to demonstration has characterized all of the six succeeding administrations, to the present time, and although Congress subsequently intervened, at a late date, to require a test to be made, it is now proposed to destroy the automatic results which have been secured, prior to the establishment of the equilibrium of the active agencies, as will appear from the sequel as set forth in this brief narrative of events.

In the Historical Résumé herewith, (Appendix "A") it is shown that from 1853 to 1879 (26 years) the Government hesitated to undertake work at Aransas Pass because of the reported existence of quicksands, constituting an "insuperable objection to

any such experiment," yet on the latter date it was estimated that a channel of *twelve* feet deep might be secured for $759,185 by the use of two jetties, and the southerly one was commenced in 1880.* Up to May, 1889 (10 years), there had been expended on this work $550,416 with "insignificant results" when it was suspended. Before suspension, however, it was modified to provide for a twenty-foot project, estimated to cost $2,052,543.72. It has been shown also that the work done under the Aransas Pass Harbor Co., holding a franchise from the Government, which it succeeded, rapidly scoured out the bar until the old jetty previously built and reported as having disappeared, was discovered to be in

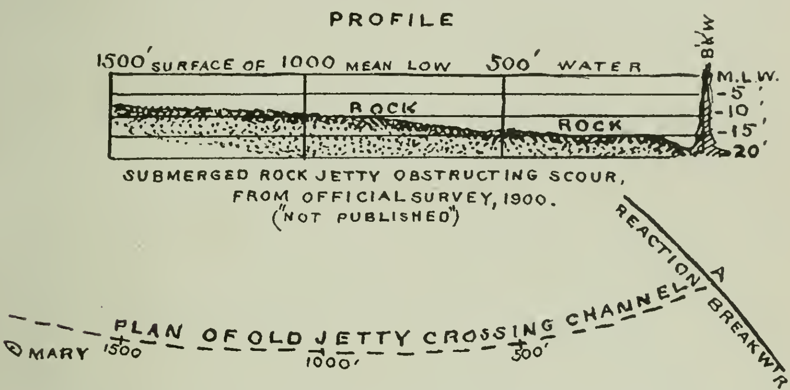


Fig. 1. Plan and profile of old government jetty between wreck "Mary" and the reaction breakwater, showing depth to rock, which prevented scour by acting as a submerged dam.

place at a depth of eight to fifteen feet, and lying directly across the channel, where it intercepted the currents and prevented further deepening, and that Congress passed the act of 1899, requiring the obstructing jetty to be removed, the work to be done in such a manner as to in no wise interfere with the curved jetty now located in said harbor. (See Fig. 1.)

It was unfortunate that this act was so worded as merely to "authorize the Secretary of War to contract for the removal," &c., so that the work was authorized and advertised September 25, 1899, at which time it was hoped that this obstruction would finally be removed and the currents be free

*Genl. Craighill, a member of the Board, objected, as he did "not coincide with the views of the officer in charge in general application or in particular at this locality," and believed that one jetty would suffice.

to complete the scouring of the channel. This same act also provided that the private corporation should surrender its franchise and the breakwater already in place at a cost to it of over $250,000, merely on consideration of the continuance of the work, and such transfer was made March 27, 1899. The Government then let the contract for the removal of the old jetty, but did not require the contractor to execute it, as it was claimed that a survey made showed it to be no longer an obstruction.

This survey covered the months of October, November and December, 1900, when 529 borings were made along the site of the old Government jetty which crossed the channel. Most of these borings only went to the rock, covering the mattress foundation, but a few were sunk to a depth of twenty feet. The map was not published, but it showed the existence of rock in place entirely across the channel at depths of from eight to fifteen feet, yet the opinion was officially published that this old sill "was no longer acting as an obstruction," and it was allowed to remain. Another act of Congress was required ordering its removal, and as the sequel shows, the last of it was not taken out until *six* years later. It constituted a serious obstacle to scour. (Fig. 1 ante.)

After thirteen months delay the Government released the contractor and requested permission of the Judge Advocate General's Office to apply the appropriation to work on the curved jetty (prohibited by the act), which it authorized on the ground that having made a contract for the removal of the old jetty, the law was satisfied. The opinion of the Judge Advocate General upon the case as submitted to him by the War Department reads in part as follows: "Whether in view of the language of the act the removal of the old jetty can be postponed, and the money appropriated be applied to the work of jetty repair and construction?" . . . to which query the reply is made, "In my opinion the act is not to be construed as requiring the removal of the portion of the old Government jetty specified therein, but as authorizing the Secretary of War to contract for its removal . . I am of the opinion that the entire appropriation can be expended for other improvements. (See Appendix "B" for more complete extracts.) The work was then, after several years of delay, let for the building up of the *inner* end of the breakwater, in violation of the design and to its injury, by causing erosion inside of

the bar and rolling it forward, which effect was to have been avoided by constructing from the outer end shoreward. This advance of the bar, with the old jetty, still in place, caused a deposit extending seaward for about a quarter of a mile with depths of thirteen to fifteen feet, there being over twenty feet at nearly all other points. (See Fig. 2, Profile of 1902.)

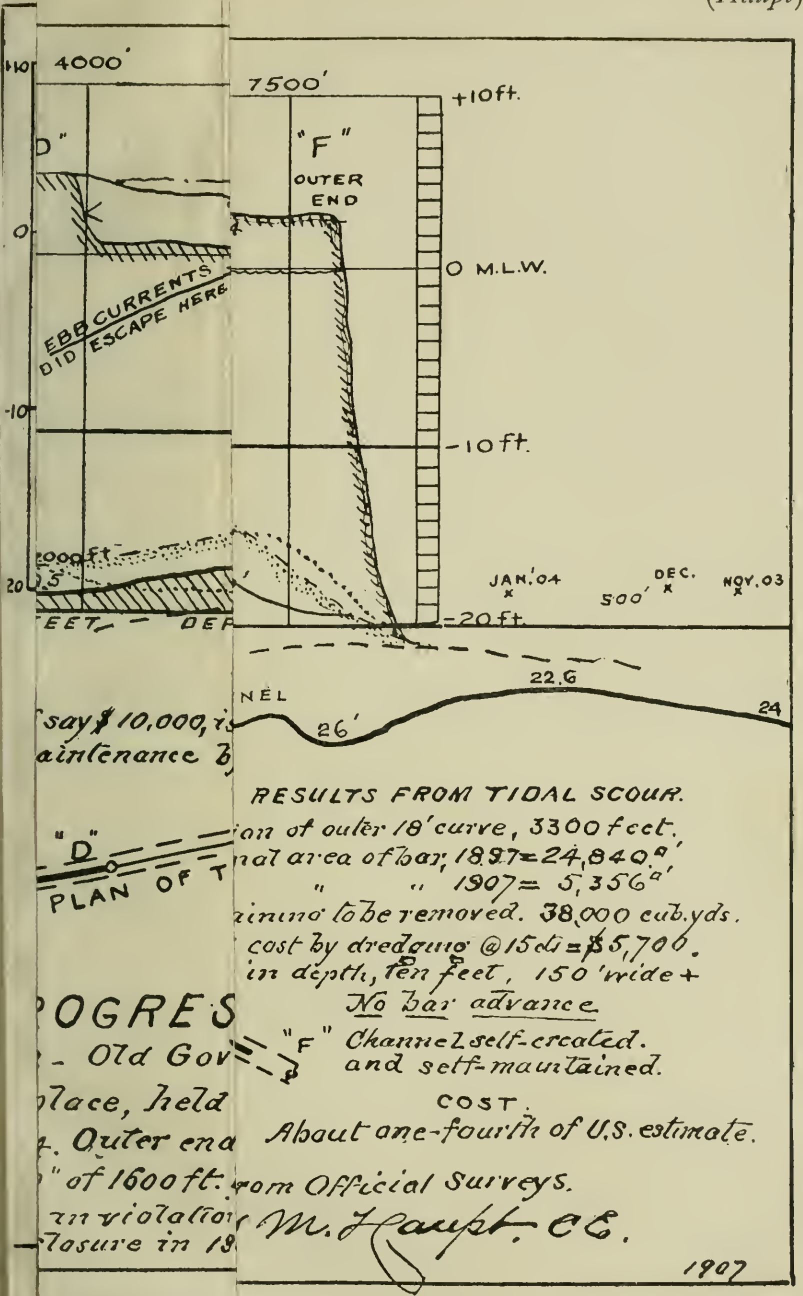
This condition of affairs made it necessary again to appeal to Congress, and accordingly, in 1902, a proposition was submitted by the Reaction Jetty Company with a memorial (see Appendix "C") offering to complete the work on the reaction breakwater and guarantee the channel for the sum of $500,000, accompanied by large bonds and forfeitures, in case the contract was awarded to that company, and to finish the same within two years. The River and Harbor Committee was unanimously in favor of its acceptance, but the item was submitted to the Engineering Department for its opinion, which was not only adverse but it was accompanied by a communication without date or signature, containing serious errors of facts, and an offer was also made by letter to place a dredge there and create the channel by that means for $100,000. It was furthermore stated that if the proposition of the company were accepted by the Committee the entire bill would be defeated, and under this view of the situation the Committee did not feel warranted in authorizing it to be done, but referred the responsibility to the Senate Committee on Commerce. Here it was opposed by the Member of Congress from the district, who refused to read the proposition, as well as by the former Harbor Company, because it had received no consideration from the Government for its previous work. While the Committee was favorably inclined toward the acceptance of the proposition to award the contract directly, it was informed by the Engineer Department that it would establish a dangerous precedent, but an agreement was made that "if Congress wished the plan tested it would be carried out by the U. S. Engineers in good faith." Accordingly the plan and rights were turned over to the Department with an appropriation of only one-half of the amount necessary to complete it. In view of the sequel the language of the act passed June 13, 1902, is important. It reads as follows:

"*Improving Aransas Pass, Texas.* Continuing improvement

$250,000; Provided, That the work at this harbor shall be confined to the completion of the north jetty in accordance with the design and specifications of the Aransas Pass Harbor Company, and in continuation of the work heretofore carried out on said jetty by said company, and to such additional work as may be necessary for the strengthening of such jetty, and for the removal of such part of the old Government jetty and any other hard material which may interfere with the formation of a channel by the natural action of the currents."

The clause herein providing for the "strengthening of such jetty" would have enabled the Government to enlarge the dimensions and height of the breakwater, thus adding greater pressure on the base, offering more resistance to wave action, without controlling more current, but increasing the cost and liability to deterioration, as well as the time to complete, as was shown in the specifications subsequently issued, which added twelve per cent. to the sectional area of the structure—without corresponding benefit.

Soon after its passage an offer was made to assist in the preparation of the specifications so as to have them conform to those of the Company, but it was declined. When they were issued it appeared that with the exception of the citation of the act, there was no reference to the plans and specifications of the Aransas Pass Harbor Company's method or plans contained therein, so that it became necessary to call official attention to this departure from the express terms of the act, and the Secretary of War required them to be recalled and modified accordingly, which was done merely to bring them into substantial accord with the plans of the Aransas Pass Harbor Company to avoid further delay. The next move was a proposition to reject all bids on the allegation that they were excessive, but before doing so a former U. S. civil engineer, having faith in the plans and desiring to have the demonstration completed, a man who had been in charge of the Galveston works for nearly twenty years, offered to undertake this work at a lower figure, and his bid was accepted, after he had first filed his bonds to take the contract. It was divided, so that $50,000 of the money was made available for the removal of the old jetty, given to another party, and the balance, $200,000, for the continuation of work on the breakwater, thereafter called



shoal from failure to cl

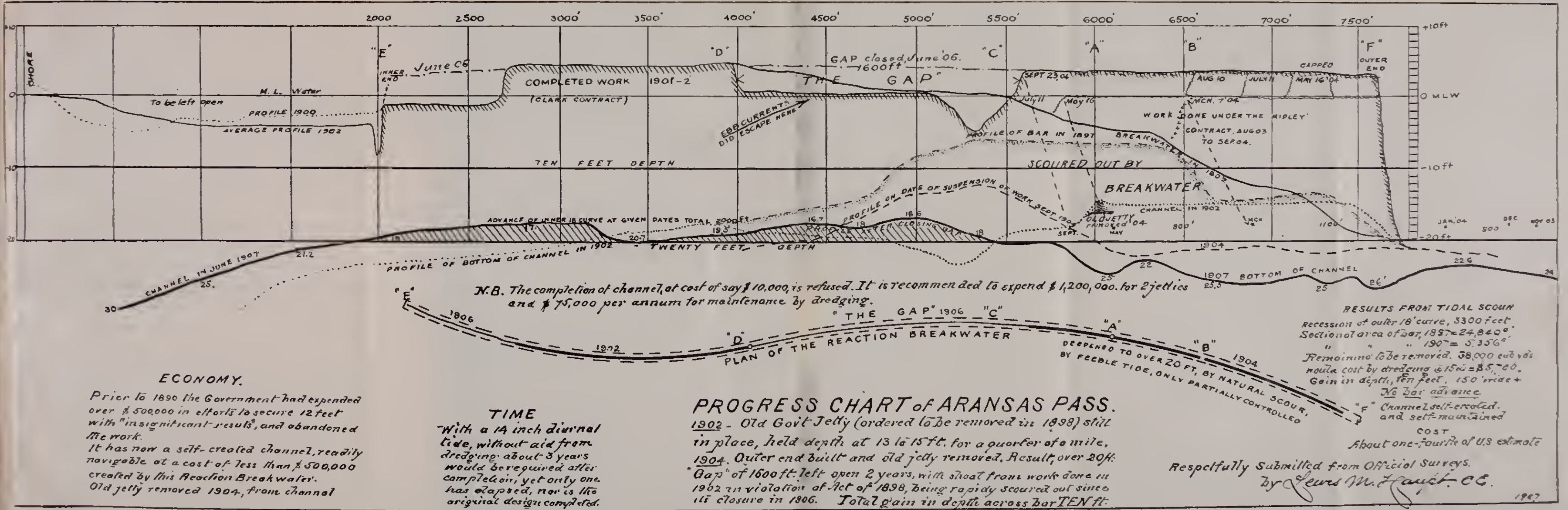


Fig. 2. Progress chart and profile showing the recession of bar by rapid scour as work at outer end proceeded and shoal from failure to close gap promptly, with subsequent improvements and bar almost entirely scoured out by natural action of currents.

the "north jetty," by the Government, beginning at the outer end, in the open sea, and extending shoreward.

The contract was finally awarded him and the work was commenced in August, 1903, after a series of mishaps to his plant and the wrecking of his tug, the refusal of the Government to permit the capping to be placed for nine months, the rejection of blocks, &c. But space does not permit the recital of the detailed obstacles which beset his path, from beginning to end, including the quarantine from yellow fever. It is the result which is the subject of this recital, and the difficulties which attended the demonstration from beginning to close. His work was faithfully performed and the appropriation of $200.000 was exhausted by September of 1904, by which time the outer half mile was completed. The old jetty was also *reported* as finally removed under the separate contract, by blasting but without dredging, so that the currents were partially freed after nine years, to work upon the bottom of the channel, yet they were not fully under control, for there was a gap left in the middle of the breakwater between the portion previously built at the inner end in violation of this plan, and the work just finished, of 1600 feet, through which the ebb currents escaped and the sand entered, thus forming a shoal with about sixteen feet depth upon it at low water. (See Fig. 2.)

RESULTS OF OUTER CURVED PORTION OF BREAKWATER.

As fast as the work was raised to the surface the scour became marked, the contours receded rapidly, cutting out a channel of over twenty feet and throwing the material over to the westward, building up a counterscarp automatically, and leaving an ample width under the lee of a perfect and continuous aid to navigation. These progressive changes are shown in the accompanying profiles of the thalweg of the channel and the breakwater with dates attached, indicating the relation of the work as it progressed to the depths secured. At this juncture a general emergency bill was framed with the expectation that it was to provide for the closure of "the gap," and the contractor had consented to continue work while his plant was on the site, upon the same terms, but the Department finally concluded that this work did not fall within the purview of the act passed April 28th, 1904, for the

"restoration or maintenance of channels." The first objection made was based on the assertion that this was not a Government work, although it had been conveyed to the United States and Congress had made an appropriation for its continuance, but when this position was shown to be untenable it was thus claimed by the Government Engineer that "no such deterioration had occurred as to justify an apportionment." The sequence of this refusal to close the gap was that the work was suspended and left in an unfinished condition for a year longer, or until another bill could be passed. The policy of the Department is clearly stated in a letter from the local officer in charge to the Chief of Engineers, written May 31st, 1901, or more than two years after the work done under the patent had been conveyed to the Government. The letter states; "So far as I am informed, there never has been any proposal on the part of the United States to make use of Professor Haupt's patent at Aransas Pass. Existing projects for that locality are based upon the plan of a Board of Engineers, which contemplates the use of two jetties, is radically different from the plan of Professor Haupt, and cannot therefore infringe on his patent. . . . The United States has not used his patent there, nor does the existing project contemplate its use." Yet this Board of Engineers, in its report, so modified its two-jetty plan (see Fig. 3) as to provide for the removal of a "small part of the curved breakwater and utilization of the balance, as it would cost less than the approved Government plan," but notwithstanding this embodiment of $250,000 of jetty work and the removal of several hundred thousand yards of sand from the channel by natural scour it reported that the value of this work to the Government "is nothing," and took it over without consideration as an essential part of the proposed "north jetty." (Vide, Doc. H. R., No. 137, 55th Cong. 2d.) Still further, it was recently testified by the officer in charge at Galveston, that on July 14, 1902, the Acting Chief of Engineers . . wrote to his predecessor as follows:

"The item for Aransas Pass does not mean that Congress has adopted the Haupt plan further than that a fair trial of the plan of the Aransas Pass Harbor Company is desired. Mr. Haupt made a strong appeal to the Committee of the House for a contract to complete his work for the sum of $500,000 . . . Many

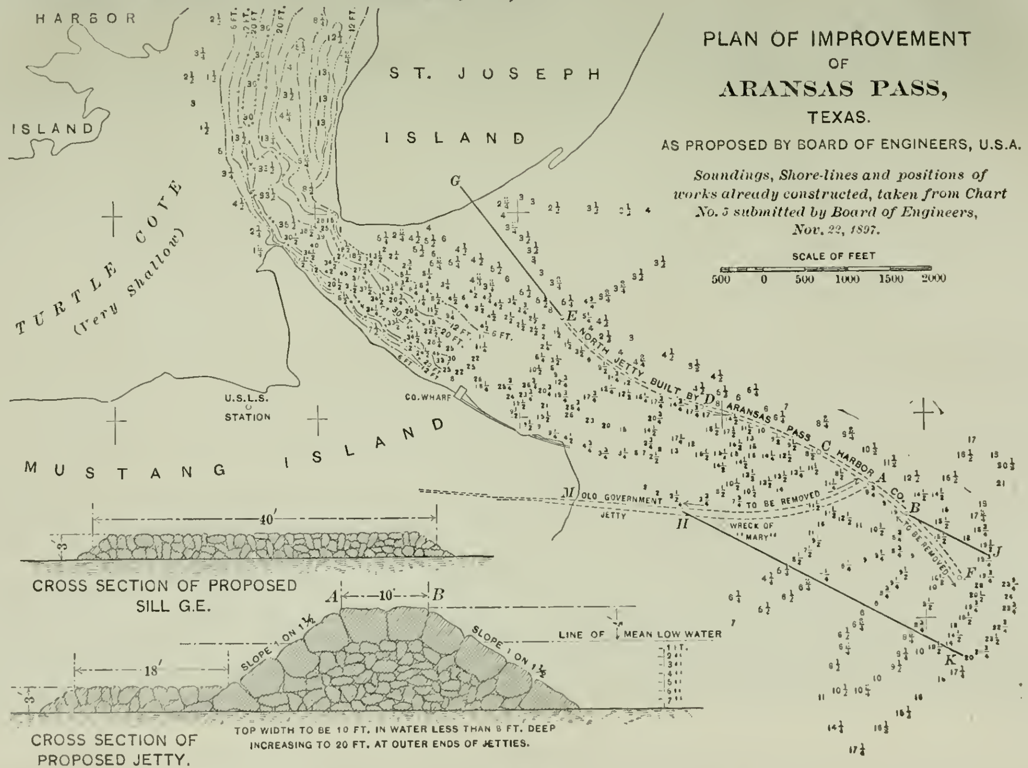


Fig. 3. Embodiment of the reaction breakwater in the two-jetty plan, as proposed by the government, at an additional mated cost of $1,525,000, and later with $75,000 annually for maintenance.

of the Members appeared to desire a test, and the wording found in the act was prepared by an officer of this office with a view and a promise that a full and fair test of the Haupt scheme for Aransas Pass should be provided for." . . . "The item regarding the removal of the old dam was also introduced with an object; it was claimed that such remnant of dam interfered with the full result, and its removal was promised." The officer of the district also testified that he gave interviews to the press reporting that the work was a failure, even when it was far from complete and before this obstructing "dam" had been removed, and that the two-jetty plan was essential to success.

In this connection it may be well to state that to establish its priority and form the basis for the organization of a Company to make tenders to carry out the work of economically improving our harbors upon the "no cure no pay" plan, as was done by Capt. Eads and others, a patent was applied for and granted in 1888, and under it a million dollar company was organized and tenders made without charge for any royalties for use of patents for the opening of the channels at the mouths of the Columbia, Mississippi, Hudson and other rivers (see Figs. 4, 5), which proposals were accompanied by guaranteed depths of thirty-five feet by natural scour, and which had they been accepted, would have saved to the Nation not less than $20,000,000 in the cost of construction and a larger sum for maintenance. These proposals were referred to the Boards of Engineers, which rejected them, suppressed the tenders from the reports made to Congress, and also declined to permit the Company or its officers to inspect their findings, although the Secretary of War had agreed to a rebuttal. In consequence the Reaction Jetty Company was dissolved. On the third of March, 1905, an appropriation of $100,000 was made to continue the work upon these plans, the language being: "Provided further, that the amounts herein appropriated and authorized shall be applied to the completion of the project in accordance with the design and specifications of the Aransas Pass Harbor Company, and in continuation of the work heretofore done, and to such additional work as may be necessary for strengthening the jetty." Under this act the work was resumed August 9th, 1905, and "completed" June 11th, 1906. The report for that year published a map showing a minimum depth of over sixteen feet, at

Fig. 4. Location of reaction breakwater for mouth of Columbia river, Oregon. (See black concave curve.) Channel over 35 feet for $2,500,000, Guaranteed. The deep channels are the natural reaction depths cut by currents.

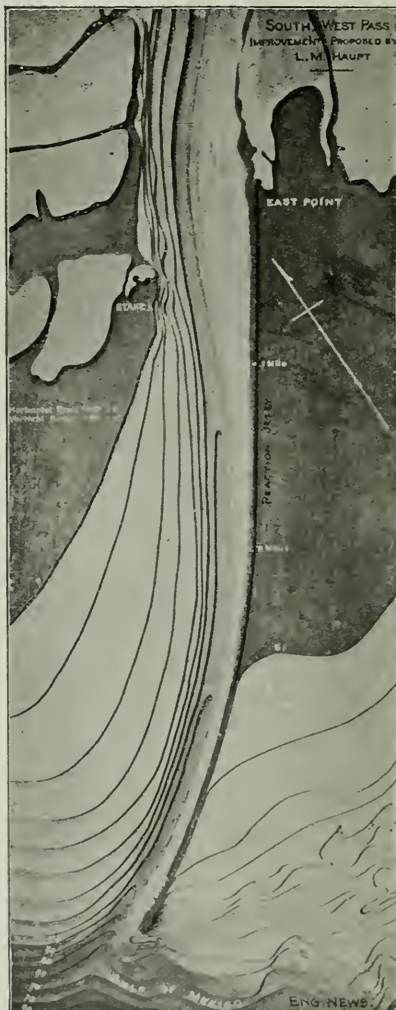


Fig. 5. Reaction jetty as applied to the mouth of the Mississippi at Southwest Pass, guaranteed to create an automatic 35-foot channel for $6,000,000, with over 100,000,000 cubic yards of sediment moving gulfward annually.

only one point in the channel, abreast of the former gap, and considerably over twenty feet for the half mile at the outer end, completed in 1904. It gives no description of the channel nor its great improvement over the original six feet, other than to state that "a rock lump with 16.5 feet of water on it was brought to the attention of this office near the close of the year. It is believed to be a part of the old Government jetty overlooked by the inspectors." The present report (1907) from the new local officer states that this lump has been removed, but it is silent as to the depths or condition of the channel, and although a survey was made in June, 1907, showing still further deepening and improvement, it is not published. (See Figs. 6, 7.) On the contrary, within about six months of the closure of the gap a Board of Engineers was called upon to report upon the conditions at the Pass, and on the 6th day of December, 1906, after a visit to the site and public hearings, it stated that "The Board has not sufficient information upon which to base an opinion as to what is now the best method to be pursued to obtain a suitable entrance channel across the bar, nor what the cost of such a channel would be, nor as to the probable location of and the means of connecting the deep water of the Pass with the commercial port that may be expected to develop. Such data can be obtained only by an additional examination and survey, which is recommended."

Thus it recognized that there was a "*deep water*" *channel* at the Pass which it was desired to connect with the proposed new terminals in the bays, and that a survey is necessary before a plan and estimate can be submitted.

This report was apparently so unsatisfactory to the Department, however, that the Board was instructed to re-examine the subject, and on the 22d of the same month it reported on some data sent to it by the officer in charge of the district, in favor of a return to the original two-jetty plan of 1887, without stating reasons or alleging any failure of the reaction breakwater, which had not even yet been completed as designed, nor had there been sufficient time for the channel to have been fully formed by the natural scour of the currents. The Board approved the recommendation, and the rough estimates amounting to *more than a million dollars,* but made the significant suggestion that in its opinion sufficient time had not elapsed for the effects of the work to become manifest and placed the responsibility upon Congress,

accompanied by a preliminary appropriation in the bill of $490,-000 for the beginning of this work on the two-jetty plan, with an estimate of $75,000 *annually for dredging*, which had been rigidly prohibited hitherto. Thus the work of destruction of the breakwater was inaugurated. At that time no survey had been made since the previous June (1906), when the rock from the old jetty was found limiting the depth to 16.5 feet, while the channel was, and still is, steadily improving. In addition to this the bill carried nearly $300,000 for interior channels from Aransas Pass to Corpus Christi and Cuero, due to the additional depth already available across the bar in consequence of the scour from this work, upon which only about $500,000 in all appears to have been expended by the Government, instead of over two million, as originally estimated.

Moreover, before this bill became a law, the Chief of Engineers sent a communication to the Senate Committee, dated February 16, 1907, only eight months after the gap was closed, stating, *inter alia*, that "The work has not been successful in obtaining and maintaining such a channel as was promised."

In this statement he overlooked entirely the qualifications as to the *time* required to develop the channel by natural scour, for when asked by the Chairman of the River and Harbor Committee, in 1902, how long a time it would require, the writer made this reply: . . . "It is unsafe for any man to prophesy . . . but in the light of past experiences and under ordinary conditions, I should say that the deepening might be expected to take place at Aransas Pass at the unusually rapid rate of about eighteen inches per annum, so that to get six feet would require about four years. The process would be slower towards the end of the work in consequence of the longer channel and larger amount of material to be removed as the channel deepens. . . . At Dublin,* the most successful on record, the rate was less than three inches per year. . . . It would be a mistake in my

*Vernon-Harcourt says: "The results of these works (at Dublin) have been most satisfactory, as sown by the profiles of the channels in 1819, 1856, and 1878. Ten years after the completion of the north wall, the bar had been lowered five feet, and in 1861, the total increase in depth amounted to seven feet, and reached nearly to ten feet in 1873." (See Rivers and Canals, p. 239.)

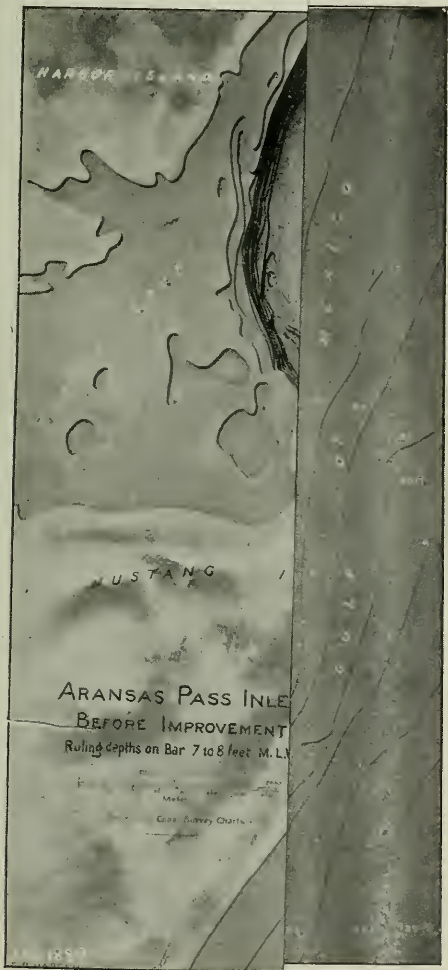


Fig. 6. Condition of bar off Aransas Pass aft in 1889, the south jetty as built,
hav

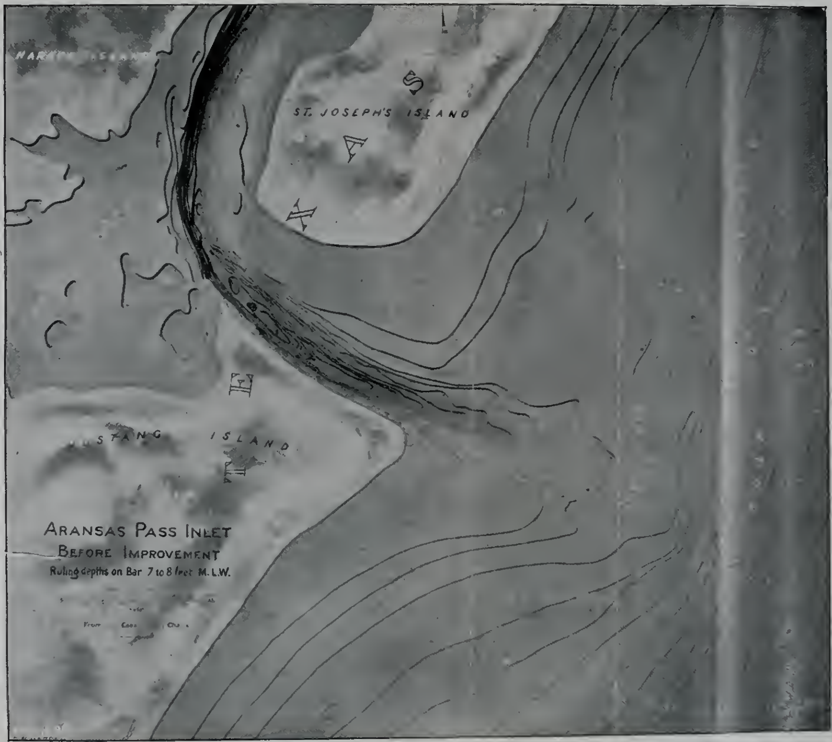


Fig. 6. Condition of bar off Aransas Pass after the suspension of work by the government on the proposed two jetty plan in 1889, the south jetty as built, having been covered with the drift and reported as having "disappeared."

judgment, to tie up the commerce of the country, while awaiting the tardy process of natural erosion, when a little aid (from dredging) would secure immediate and permanent results." But the Committee wished to test the currents and no dredging of the channel was permitted.

At the date of the closure of the gap the depth lacked less than four feet of the predicted twenty, so that at the rate stated of eighteen inches per annum it would have required nearly three years after the work was "completed" before this test could be said to have been fully and fairly made, but as the amount of silt remaining, as shown by the survey, was less than 40,000 cubic yards, which could have been removed for about $6,000 in a few weeks and thus have completed the channel, I requested that Congress make this small amount available out of the appropriation of the $490,000 to hasten the formation of the channel, believing that the remainder would not have to be expended, but this was declined.

Further, the Chief Engineers informed Congress that "In my opinion the adoption of the Haupt plan for improving this harbor has resulted in adding greatly to the expense which will ultimately be necessary before a deep draft* can be obtained." As the original Government estimate, which guaranteed nothing, was in excess of $2,052,000, and as the present estimate to complete, including $100,000 for a dredge, is $1,288,699—and the Government has already expended say $500,000, it would make the total cost by the utilization of the work already done, excluding the dredge, about $1,688,000, or more than $300,000 less than the first estimate, but it will certainly cost far more to create and maintain the channel at $75,000 per year, as estimated, than would be the case if nature were permitted to do the work herself, or if the $6,000 were applied to open it by dredging immediately. He concludes, nevertheless: "Far from Mr. Haupt's plan having in any degree benefitted the Government, I think it has injured it greatly. . . . I know of no other localities at which Mr. Haupt has tried his plan, or accomplished any results. . . . I do not recommend the enactment of any legislation such as he suggests."

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*The project was for a twenty-foot draft, and it is expected that the reaction jetty will give about twenty-five or more.—L. M. H.

It is needless to add that no dredging was permitted to remove the small amount of material to complete the channel, in far less time than had been predicted, and under exceptionally unfavorable conditions. During the past year, not only have there been no severe "Northers," so important for scour, but the winds during the summer season have prevailed from the South, driving the beach sand into the face of the breakwater, cutting off about 1000 feet of Mustang Island and rolling it into the channel, yet the last reported depths were from eighteen to over twenty feet all the way across the bar. In fact it was credibly stated, early this month, that the twenty-foot depth had been cut through. This can hardly be anticipated until after another winter at least shall have passed and the inner flank of the Breakwater shall have been constructed as originally designed, to arrest cross-currents.

RESULTS.

As to the measure of success which has been attained by the system so far as it has been completed, it may be well to add that the official reports of the Life Saving Service, stated on August 16th, 1906, or two months after the closure of the gap, that "the breakwater gives a depth of fifteen feet with sufficient width for safe navigation of vessels of such draught." On July 12th, 1907, it is said, "The least depth found on that occasion (in May) was eighteen feet. The tide may have been eight to ten inches above mean low, but it is approximate." This would indicate a gain of over two feet in nine months, covering one of the mildest winters known in twenty-five years.

A Government official, in forwarding a copy of the last survey of June, 1907, volunteers the statement that "It (speaking of the channel) shows large—twenty feet over the bar with some shoaler spots in the upper portion of the channel where the work evidently should be temporarily assisted by the use of a dredge."

Notwithstanding the evidence of Nature and the testimony of disinterested witnesses, as well as the opinions of experts, and the lack of sufficient time to complete the test, it appears that the tragedy is about to be enacted of appropriating a large sum from the National Treasury to put a quietus upon this test, before it could have secured the channel under any possible natural conditions.

UTILITIES OF THE SYSTEM AS GUARANTEED.

Some of the benefits which might have accrued to the Government from its adoption since 1887 may be briefly summarized as follows:

The saving in construction at Aransas Pass, about	$1,500,000
The saving at Galveston, as proposed prior to present plan	6,000,000
Reduction made in estimate at Southwest Pass	7,000,000
Guaranteed plan at mouth of Columbia (see Fig. 4) saving	4.500,000
Automatic training wall for Ambrose channel, saving	1,500,000
Total saving in cost of construction alone	$20.500,000

The cost of maintenance if capitalized at five per cent. would probably aggregate an equal sum.

The Government plans have been radically changed since the submission of this system to Congress, and it is becoming generally the policy to-day, where practicable to build up the *windward* jetty first, beginning at the outer end and building shoreward, thus securing immediate results, although the simultaneous construction of the leeward jetty has the effect of preventing the lateral distribution of material and compelling the bar to move seaward, while the straight form prevents the "continuous reaction" and reduces the scouring effects of the effluent curents.

At the Southwest Pass between 1898 and 1906, the average shoaling for the outer eight miles at the bar, has been 1.55 feet, while the maximum shoaling in channel abreast of Stake Island has been about fourteen feet, and the latest survey indicates an advance of over a half mile of the bar and a still further shoaling on its crest, the ruling depth in the channel being about twenty-one feet with dredges fully employed and the two-jetty plan almost finished. At Galveston, a bar has formed entirely across the 7,000 feet interval separating the jetties and the channel is flexed so that the crossing is now south of the South jetty, with the curvature much sharper than at Aransas Pass. These few illustrations may serve to show the serious nature of the problem of removing ocean bars and the desirability of opening these contracts to any one who may be willing to undertake them under satisfactory safeguards for, as well as from, the Government.

APPENDIX "A."

BRIEF HISTORY OF EFFORTS TO SECURE A HARBOR ENTRANCE AT ARANSAS PASS, TEXAS.

EARLY SURVEYS.

On January 13, 1853, Capt. Geo. B. McClellan reported that the channel over the bar shifted in one week from the north to the south breakers, creating a new depth of nine feet and leaving four feet in the old bed, causing the wreck of three vessels in as many days.

In 1854, a reconnaissance was made by direction of Prof. A. D. Bache, Superintendent of the United States Coast Survey, showing nine feet on the bar, with the inlet extending South-east from the site of the proposed light house on Harbor Island. Since then the inlet has been traveling southwesterly at an average rate of about 260 feet per annum with corresponding deteriorations in channel depths. (One mile in twenty years.)

1869. The first attempt at improvement, made in 1869, was a private enterprise consisting, of wooden hurdles filled with brush and extending for a length of 600 feet from St. Joseph's Island "to cut off a secondary channel." This temporary jetty caused a shoaling of two feet in the secondary and a like deepening in the main channel so long as it remained in place. It was on the *north* side.

GOVERNMENT WORK.

In 1871, Capt. C. W. Howell, U. S. E., forwarded a report from the late Lt. Woodruff, stating:

1871. "The cost of building a jetty from Mustang or St. Joseph's Island towards the bar, which would be able to resist the action of the storms upon the quicksand foundation, must be an insurmountable objection to any such experiment." This opinion was endorsed by Major Howell in these words: "I coincide with Lieut. Woodruff in the opinion that all the plans suggested and discussed by him offer no certainty of producing good results, and that the expense which would be incurred by testing them will be out of all proportion to the benefits derivable from success."

1879. A Board of Engineers reported August 9, 1879, that to obtain twelve feet of water by the plan recommended by it, of two parallel jetties 3000 feet apart, the cost would be $759,185. The depth shown at that date on the chart was seven feet on the crest of the bar. The Board considered that one jetty on the *south* side might suffice, but the improvement would not *necessarily* be permanent. For this single jetty to produce twelve feet, the estimate was $432,980.

BEGUN MAY, 1880.

1880. In May, 1880, work was begun on the single jetty extending from Mustang Island. A storm in August of the same year destroyed a large part of the work.

1883. In 1883, the citizens of Rockport and Corpus Christi subscribed

$10,000 to continue the contract, and with other moneys appropriated by Congress, work was continued until April, 1885, when it was suspended. The jetty was then 5,500 feet long, of which 1500 feet was on shore. Of the remainder, 3,300 feet was built up to ordinary high water at the inner end, while the outer portion was from three to fourteen feet below water and crossed the channel. No north jetty was built. The cost to July, 1887, was $393,556.95.

1887. "In view of the injury sustained by the works and the lack of results, a new survey was made in March, 1887, under the direction of Major Ernst, U. S. E." He reported that "The single jetty had but an insignificant effect, giving only eight and a-half feet depth, and that the channel was across the jetty, which was in a dilapidated condition." He submitted a new project to secure twenty feet by parallel jetties, 2000 feet apart, estimated to cost $1,688,500, and added "The original estimated cost of this work, as here revised, is $2,052,543.72."

1888. The next Report, 1888, page 1314, states also that "the curved "portion of the jetty has practically disappeared," etc. "The effect of the work upon the bar has been insignificant."* The revetment of the head of Mustang Island was however continued until May, 1889, when work at the Pass was suspended.

1889. The Board appointed, March 2, 1889, recommended the concentration of expenditures upon the work at Galveston, but stated that the Harbors of Sabine and Aransas Pass were worthy of great consideration. Work ended May, 1889.

PRIVATE WORK RESUMED.

The Aransas Pass Harbor Company was incorporated March 22, 1890, and the Government relinquished the work June 30, 1890, after expending $550,416.58. The estimated value of the work in place was

For the "old jetty from shore to wreck of Mary"	$68,400.00
And for the revetment of Mustang Island	163,307.41
	$231,707.41

From which it would appear that there was none of the jetty remaining beyond the wreck of the "Mary." The Company was to secure twenty feet of water by 1899 under the State grants and the franchises granted by Congress. These have been twice extended, to January 21 of the same year.

On November 22, 1897, a Board of U. S. Engineers reported that the Company had exhausted its resources and had suspended work on the bar "without obtaining a greater navigable depth than 8.5 feet." Yet the chart showed 9¼ feet and great reduction in the size of the bar. The Company's first efforts consisted of a jetty built on the *south* (or wrong) side of the channel in 1892, composed of wooden cylinders, seven feet in diameter, sunk vertically by the water jet and filled with sand, but this not proving

*In 1891, the U. S. Coast Survey plans showed only seven and one-fourth feet on the bar.

sufficient after several years of labor, during a period of great depression, the Company was reorganized upon a basis of a land bonus of $400,000 and the reaction breakwater, as planned by Prof. Haupt, was introduced.

Instead, however, of entering into a contract for the entire work as designed, the Company was only willing to construct about half of the necessary breakwater and entered into a contract, on July 3, 1895, with Charles Clarke & Co., of Galveston, for the sum of $145,000 to complete this portion of the breakwater.

Work was commenced in August, 1895 and prosecuted so rapidly that by November of the same year *(less than three months)* the remains of the curved portion of the old Government jetty, built across the channel prior to 1885, and reported to have disappeared in 1888, were discovered in place, *covered with rocks at depths of from 11 to 13 feet.* This obstruction prevented further scour, making it impracticable to secure the predicted fifteen feet, until its removal, which was strenuously urged by the consulting engineers, but not executed by the Company. Instead, it extended the inner end of the breakwater and raised it to the surface, hoping thus more effectually to control the ebb currents, which were powerless to scour out this rock-covered sill.

1896. In this emergency, Col. C. P. Goodyear, of Brunswick, Ga., made a proposition to remove the obstructing Government jetty, and complete the entire breakwater for a lump sum, conditioned on results, and on September 12th, 1896, the contract with him was executed. The contractor exploded some 13,000 pounds of dynamite on the jetty, making a breach several hundred feet in length, and thus detaching the outer portion, although not removing it from the channel, but in consequence of his inability to obtain the funds from the Government for the results believed to have been secured at Brunswick, Ga., in time, he was obliged to suspend operations at Aransas, at considerable loss, in the Spring of 1897.

The breach made by Col. Goodyear, however, enabled the currents to pass through the outer portion of the bar and to continue their work, though enfeebled by the submerged jetty so that notwithstanding the prevalence of the strong South-east winds, driving large quantities of sand northwardly during the summer months, there was thereafter reported a progressive improvement in the depths over the bar, with the breakwater incomplete and the currents not then under adequate control.

1898. An examination of the bar, made on August 2, 1898, by competent engineers and sailing masters, revealed more water than had ever been reported for this location, and showed a remarkably well defined, fixed channel readily navigable for sailing vessels. This, too, notwithstanding the fact that no work had been done for over a year and that the season was very adverse to the maintenance of a good channel. The partial breakwater had built its natural counterpart of sand, solely by the action of the currents, sweeping out and reacting on the concave face of the structure, which does not appear to have settled after these several years of exposure.

Concerning the results secured up to that date it was reported by a resident of the Pass as follows:

"Having been stationed at the Aransas Pass Inlet since 1886, and being familiar with the depths of water on the bar, it gives me pleasure to say that since work was stopped on the unfinished breakwater, in 1897, there has been a continuous deepening and improvement in the channel, which is at present deeper than I have ever known it to be. This at a time of year when the South-east winds usually cause shoaling, but the currents now partly under control are able to maintain the channel they have created."

On the completion of the first contract, the Resident Engineer in charge reported to the Harbor Company the following results:

"The results which have been attained by the construction of this breakwater are satisfactory and marked to a degree. Considering the fact that the deep water lines are drawing closer together, the distance from twenty feet depth of water in the Gulf to twenty feet depth inside the bar being 3,500 feet, against 6,200 feet at the start, whilst the fifteen and twelve feet lines have made more material advance and the depth of water, the bar having deepened permanently three feet in a short space of time, there should be no reason to doubt that as soon as the currents have been controlled by the completion of the entire breakwater the anticipated results will be forthcoming." . . . .

"When the breakwater shall have been built up to its full height and length as proposed by the Consulting Engineers, there can be no question that the channel will deepen rapidly and permanent deep water secured. The sands carried by the flood tide will then be intercepted and the ebb discharge will be concentrated and restricted in its escape through the channel.

"The portion of the breakwater already built has had the effect of intercepting the sands of the flood tide, as the water is now shoaling north and east of this breakwater and the conditions of equilibrium of the flood and ebb currents are perceptibly changed."

Further, on the 11th day of February, 1899, Captain Welker, in command of the U. S. Coast Survey Steamer "*Bache*," engaged in making a complete survey of the Pass, wired the office, that there was a clear channel depth of *fifteen* feet entirely through. This was followed by a letter reporting that the weather conditions were so bad as to prevent surveys on the bay more than about one day out of each week. In his official report he also states:

"In 1895, the Aransas Pass Harbor Company constructed a jetty in the shape of the letter "S," on the north side of the entrance, which is still in existence, and ever since its construction there has been a marked increase in the depth of water on the bar. The present channel crossed the Mansfield Jetty, portions of which are still in position. An attempt was made to remove this by explosion of dynamite, with the result that the rocks scattered over considerable area and without doubt they prevented the current from scouring the bottom to its full capacity.

"It is my opinion that, by the completion of the present jetty and the clearing away of the rock in the entrance a channel of at least twenty feet in depth would soon be secured."

On the other hand the Board of U. S. Engineers, in reporting on this work shortly after the suspension of the Goodyear contract, said:

"It was thought by the Company's engineers that the old Government jetty acted as a dam to prevent further deepening. This jetty was therefore blasted out over a length of about 500 feet. This blasting was followed by an advance of the inside contours." . . .

"There does not seem any probability that the jetty, as now constructed, will of itself secure and maintain any considerable increase of depth in a navigable channel of proper width."

Notwithstanding this guarded prediction the Welker report shows a progressive deepening from the eight and a-half feet, said to be the least depth, to fifteen feet, in a little more than a year with no additional work done at the site—and the latest reports, after the plan is said to have been completed (in 1906), are that the depths reach to from eighteen to over twenty feet entirely across the bar, which it is now proposed to destroy by a return to the original project of 1887, as recommended by the Board of U. S. Engineers for the purpose of maintaining a channel which is already *self-created* and readily navigable.

APPENDIX "B."

COPY OF OPINION OF JUDGE ADVOCATE GENERAL

As based upon the communication of the Chief of Engineers as to the appropriation made for the express purpose of removing the old Government jetty obstructing the channel scour at Aransas Pass, Texas. It reads:

December 17, 1900.

"Respectfully returned to the Secretary of War,

The River and Harbor Act of Mar. 3, 1899, contains the following item:

"Improving Aransas Pass, Texas. For dredging and other improvements of Aransas Pass Harbor, sixty thousand dollars; Provided, that the Secretary of War is hereby authorized to contract for the removal of that portion of the old Government jetty in said harbor from the end nearest to the curved jetty constructed by the Aransas Pass Harbor Company to the wreck Mary, in such manner as to in no wise interfere with the curved jetty now located in said harbor; And provided further, that said contract shall not be let by the Secretary of War, nor said work done, until the said Aransas Pass Harbor Company shall have properly released and surrendered all rights and privileges heretofore granted to it in said harbor by Congress, also the jetty constructed in said harbor." (30th Stats. 1128.)

In 4th endorsement hereon the Chief of Engineers says:

"The requirement as to removal of old Government jetty was introduced in the item by Congress and in accordance with the requirement a contract was entered into in January last, with Charles Clark & Co., but in the opinion of the Engineer officer in local charge of the work it would be to the interest of the work to postpone removal of the Government jetty as contemplated by the act and contract made in accordance therewith

until other and more important work had been accomplished. The District Engineer officer, Captain Riche, recommends that, instead of removing the old jetty at this time, the available funds be applied to repairs to what is known as the "curved jetty," and to dredging, surveys and contingencies, etc. He proposes to annul the present contract for removing the old jetty, no work having been done under it and the contractor being willing, and to make, without advertising, a new contract amounting approximately to $75,000 in its stead, on terms considered by him very reasonable and advantageous, covering the work of jetty repair and construction considered essential at this time."

The matter has been referred to this office for opinion.

"1. Whether in view of the language of the act the removal of the old jetty can be postponed, and the money appropriated be applied to the work of jetty repair and construction proposed by Captain Riche."

"2. Whether it would be legal to abandon the present contract, by mutual consent, and substitute therefor a new contract with the same parties, covering the new work, without inviting competition by public advertisement."

"In my opinion the act is not to be construed as requiring the removal of the portion of the old Government jetty specified therein, but as authorizing its removal. An appropriation of sixty thousand dollars is made generally "for dredging and other improvements of Aransas Pass Harbor," and this is followed by the provisions that "the Secretary of War is hereby authorized to contract" for the removal of the portion of the jetty referred to. There appears to be nothing in the act which limits the expenditure of the appropriation, or any portion of it, to the removal of this jetty; and I am of opinion that the entire appropriation can be expended for other improvements. No objection is seen therefore to a supplemental contract with Charles Clark & Co. providing for the termination of the existing contract for the removal of the jetty, provided such action is deemed for the best interests of the United States."

As to the second point it was ruled that it could not be legally done without public advertisement.

The case as presented makes the opinion of the District Engineer superior to the decision of Congress as to the necessity of removing the obstruction which the Government itself had previously placed across the channel and which it persistently declared was not acting as an obstacle, even after a survey involving over 500 borings showing rock in place at depths of from eight to thirteen feet, had been made but not published.

It is a fact that the River and Harbor Committee in executive session called the writer before it and asked him what the cost of the removal of that obstacle would be, stating that it was the desire of the Committee to make a test of this method, and if the prediction of fifteen feet resulted from this part of the work, after the removal of the obstacle, then Congress would complete the work upon this plan, but that the whole matter was contingent upon the taking up of this obstacle. It was stated to the Committee that it could be done for $50,000, and the Committee made it

$60,000 to cover any possible contingency, and voluntarily inserted the proviso that the curved jetty in said harbor should in no wise be interfered with, so that the work might be conducted strictly in accordance with the design of the inventor.

The authority to apply the money to the jetty, conferred by the official opinion upon the allegation that more important work of "repairs" was required, and the release of the contractor after a delay of more than a year of inactivity, and the execution of a contract with him to build up the *inner* end of the jetty first, in violation of the proper method of procedure and while the old jetty still remained to obstruct the passage of the currents seaward, resulted in great injury to the channel by rolling the bar forward and creating a shoal by subsequently leaving a breach of about 1600 feet in the center of the work, for several years, thus enabling the currents to escape and the drift to enter the channel, still further delaying results.

All this was the sequence of the failure to execute the provisions of the act of 1899 in accordance with the expressly stated purpose of Congress. The old Government jetty was not removed until 1904, and even then a rocky lump remained with less than seventeen feet depth, which was only taken out in 1906, thus finally, after many years of delay, enabling the currents to operate freely upon the channel. The results which have followed, notwithstanding these most serious delays and unusual obstructions, have no precedent in the annals of harbor improvements in the world, either as to economy or results, yet it is now proposed to obliterate them by the immediate return to the original two-jetty plan of the Government, before the unaided currents of this feeble tidal inlet have had sufficient time to establish a permanent regimen, as agreed upon when the plan was taken over by Congress.

L. M. HAUPT.

APPENDIX "C."

MEMORIAL AND BRIEF SUBMITTED TO COMMITTEE ON COMMERCE, U. S. SENATE, FEBRUARY, 1902.

Improving the Entrance to Aransas Pass, Texas, by Natural Methods.

COMPARATIVE SUMMARY OF RESULTS AND COST.

Prior efforts by Government and others. *No results.* Cost, $657,885. The "Haupt" plan, partially built by the Aransas Pass Harbor Co., *increased depth nine feet.* Cost, $235,000. Cost, per foot of depth gained, $26,111, which is unprecedented.

COMPARATIVE PROPOSITIONS.

The Government proposes to build *two jetties and dredge* a twenty-foot channel, which *will not be self-maintaining;* without guarantees or time limi-

tations; with no risks as to results and with no probability of continuous appropriations to complete for $1,526,000.

Prof. Haupt, if given the contract, proposes to complete his curved breakwater, now embodied in the Government plan; guarantees the channel and its maintenance by tidal scour for two years, surrenders all rights under his patents at Aransas Pass, and gives bonds for the faithful performance of his contract, for the sum of $500,000, *thus saving at least $1,025,000* in case the plan succeeds; but should the channel not be secured, he forfeits the final payment of $100,000, or should it not prove to be self-maintaining for two years, $75,000 more, thus reducing the cost of the breakwater in place to $325,000, all of which work is embodied in the Government plan, so that *it would lose nothing.* The bond of $50,000 is given to protect the Government from any damages for failure to fulfil conditions of contract.

EQUITIES.

The inventor of this plan has a deep professional interest in the proper conduct of the work; his bill safeguards the Government fully and he proposes to prosecute the plan vigorously to completion. On the other hand, if these plans are relegated to unfriendly parties to be executed, it will cost more, take longer to finish, will not release the Government from claims for infringement of patent rights, and may be entirely defeated by an improper order of construction or failure to remove the obstructing jetty.

The work has already been under the Government control for about three years, with an appropriation specifically made for the removal of the old jetty, which has not been done.

THE VALUE OF THE WORK.

The Report of the Board of Engineers, dated November 22d, 1897, states: "The value to the Government of the works of the Aransas Pass Harbor Company for the improvement of Aransas Pass, Texas, is nothing."

Up to the date of the abandonment of this Pass by the Government, in May, 1889, it had expended $550,416.58 without material improvement, while the Harbor Company subsequently expended $235,000 on the north jetty, which at the date of the report had deepened the channel from 6½ to 9¼ feet,* and it has since continued to deepen without assistance or further work, to 15½ feet, at which depth the channel is held by the remains of the old, rock-covered jetty, built by the Government and reported as having "disappeared."

The Government's revised estimate for securing twenty feet by two jetties and dredging in 1889 (vide reports of Chief of Engineers) was $2,054,343.72, and in 1898 (Doc. 119, H. R., 55th Cong., 3rd Ses.) it was

*Document 137, H. R., 55th Cong., 2nd Session.

$1,525,000.00, showing a reduction of $529,543.82 due to the results secured by the works of the Harbor Company, which were reported to be of no value.

Prof. Haupt, the inventor of the curved breakwater which has produced these unprecedented results, has proposed to Congress to complete his work and to guarantee the channel for $500,000, thus saving the further sum of $1,025,000, and he further agrees to maintain the channel for two years by tidal scour without charge, or forfeit $75,000 as a demonstration of the great value of the device, even under such adverse circumstances. He further surrenders all claims for royalties at Aransas Pass in case he is permitted to complete his breakwater at that place.

PHYSICAL RESULTS OF THE WORK.

This report also states that in the opinion of the Board,—

"There does not seem any probability that the jetty as now constructed will of itself secure and maintain any considerable increase of depth in a navigable channel of proper width."

(Vide Page 15, Document 137, H. R. 55th Cong., 2nd session.)

On the contrary, the results have shown how little the operations of the curved jetty were understood by the Board, since this incomplete structure, without any additions or aid from dredging, has caused the removal by scour of over half a million cubic yards of material, has increased the depth of the channel nine feet, at the shoalest point, has maintained and fixed the channel in position and has deteriorated less than most jetties, notwithstanding its incomplete condition, both as to length and capping. It has not been undermined nor is there even a trough near its base, while the maximum depth shown* was 25¼ feet.

All this without cost to the Government, since this is the result of the work done by private parties and turned over to the Government three years ago on condition of its being completed at once.

This progressive deepening, widening and maintenance is now arrested by the presence of the old Government jetty. Such a result is believed to be unparalleled in the annals of harbor improvements, and it has been crowned by the highest premiums from learned societies.

THE OBSTRUCTING "OLD GOVERNMENT JETTY."

This jetty was built between February, 1881, and April, 1885. In the Report of the Chief of Engineers for 1882, page 1314, it is said: "The work designed to deepen the channel over the bar was a jetty on the south side of the entrance. It was constructed upon a line running east and west to a point 2,352 feet from the shore, where it curved northward upon a radius of 2,880 feet and extended 1,698 feet further, making a length from shore of 4,050 feet.

* * * * * * *

*Vide official survey of 1900.

It was constructed of superposed mattresses ballasted with stones. . . It appears that the curved portion of the jetty has practically disappeared. Of the straight portion . . . that which was built out into the Gulf has its crest, upon an average, about three feet below mean low tide. . . . Its height above the bottom has diminished about 6.2 feet, or over 50 per cent. . . . The effect of the work upon the bar has been insignificant."

The expenditure for this experience was $393,556.95 to July, 1887.

As the work of the Harbor Company proceeded, the current scour soon revealed the existence of this obstructing jetty lying across the entire channel so that it limited the depth, and as it was not anticipated, due to the report quoted above, no contract had been made for its removal.

When the work was returned to the Government, in 1899, it immediately appropriated $60,000 for the removal of the old jetty "in such manner as to in no wise interfere with the curved jetty now located in said harbor."

A contract was let in accordance with the terms of this act, but no work was done and after thirteen months had elapsed it was annulled.

A careful survey with borings was made of the old jetty, and upon it the opinion was expressed that "It was not acting as an obstruction." (See Report, Chief of Engineers for 1901, page 1952.) The drawing was "not printed" but it shows very clearly that this old jetty is still in place, covered with rock extending entirely across the channel at depths of from 11 to 15½ feet. It is therefore an absolute barrier to the creation of the proposed twenty-foot channel or to the further deepening of the present improved one, and yet, in consequence of these representations, authority was obtained to permit it to remain and to apply the money appropriated for its removal to the part of the jetty which was not to be interfered with under the law, with the result that the work now under contract is causing shoaling and bar advance, so long as the jetty remains and the outer end of the breakwater is incomplete.

Thus all efforts to secure the removal of this serious obstacle to the creation of the channel by scour have been thwarted, and it remains a barrier to commerce as well as a bar to the demonstration of the complete practicability of the reaction breakwater.

OTHER BARRIERS.

In a recent communication* to the Chairman of the Rivers and Harbors Committee, from the office of the Chief of Engineers, occurred these statements:—

"The Government jetty contemplates an apron of stone along entire length of jetty, eighteen feet wide, three feet thick, which is not a part of the Haupt plan, and requires about 17,000 tons of stone."

A reference to the original plans of the Haupt jetty, as published in the official report, Doc. 137, would have avoided this error, as the apron of the full dimensions is there shown as it was built and from which that in the

*Without date or signature.

Government plan is copied. (See same document.) It is also stated that, "The Government plan contemplates a sill from the end of jetty to shore, etc."

If this sill is built, it will defeat the purpose of the breakwater by cutting off a large portion of the only force available for scour, and ultimately require a second jetty and dredge to secure and maintain the channel, so that it would be a fatal mistake, as there is no injury to the physical conditions by leaving it open for the free admission of the tides. This is fundamental to success.

ARGUMENT AGAINST HAUPT'S PLAN BY THE ENGINEERS.

Again it is stated: "The Haupt jetty on Government plan will cost $575,000, including sill and apron."

Such sill and apron are estimated to cost $94,250 by the engineers at an assumed unit price, which is less than the present contract price. The letter is a criticism of Haupt's bill for deepening channel at Aransas Pass, and this statement is a comparison of cost of work under his bill and work if left in the hands of engineers.

It seeks to show that there is no "apron" in Haupt's plan, which is erroneous; also, that a "sill" is needed. Although a sill is no part of Haupt's design, and would defeat its purpose, and that if the cost of sill and apron, $94,250, is deducted from their estimate with sill and apron, they will do as much with $480,750 as Haupt with $500,000.

This is in no sense a fair comparison. For they say Haupt's Breakwater will not get the twenty-foot channel and offer a plan at a cost of $1,525,000, which they say will get the water by aid of dredging. Haupt says his device will get such channel, and maintain it without artificial aid for two years at a total cost of $500,000, and agrees to forfeit $75,000 if it is not thus maintained. He also forfeits last $100,000 to be paid for breakwater if full twenty feet, 150 feet wide is not procured. He is paid, therefore, for *merely* building of breakwater, but $325,000, which would be their basis of comparison with their estimate of $480,750, without sill or apron, assuming, as they do, that neither Haupt's nor their construction of breakwater, unaided, will get the water.

The comparison, however, should be between their estimate of $1,554,-423.72, which they say *should* get the water by dredging and jetties, and Haupt's $500,000, which he believes, as shown by local physical condition, *will* get the water, and any other basis can have but one effect, namely, to cloud the real issues.

To be entirely fair, comparison should be stated thus:—

Expended by U. S. Engineers, without result, up to 1890 (on twelve-foot project)..	$ 550,416.58
Their revised estimate for twenty feet........................	2,052,543.72
	$2,602,960.30

Spent by A. P. H. Co on north jetty (gain, depth nine feet)	$235,000.00	
Bid by Prof. Haupt to complete	500,000.00	
		735,000.00
Difference saved had Haupt plan been available from the start		$1,867,960.30

Brief of L. M. Haupt and Associates to Improve Aransas Pass, Texas, for $500,000, which is less than One-third of the Estimated Cost by the Government Plan.

The proposal is to create a channel and to maintain it for two years by the natural scour from the tides, having a width of 150 feet bottom, and a depth of twenty feet over this width, entirely across the bar, by means of a single curved or Reaction Breakwater of stone, of sufficient dimensions to control the currents but not oppose too great superficial resistance to waves, for the sum of $500,000.

The work is to begin within three months and the channel is to be secured within three years or he shall forfeit $175,000 of the above amount, and he shall also file a bond of $50,000 for the faithful performance of the contract.

The work shall be done under the Secretary of War and the payments be duly certified by an experienced Government official in his department, to be designated by him.

In consideration of this contract, the said Haupt shall surrender all his patent rights to this improvement at Aransas Pass and make no claim for its use or for damages. He shall further remove the obstructing old Government jetty and complete the breakwater as designed for the Aransas Pass Harbor Company in 1895.

He shall take all risks, and in case of failure to commence or to continue the work as specified, he shall forfeit it and his penalties without delay and the work shall be continued by the Government.

The Rivers and Harbors Committee being unanimously in favor of completing the Haupt plan, proposes the following item:

"Improving Aransas Pass, Texas.

"Continuing improvement, two hundred and fifty thousand dollars: *Provided*, That the work at this harbor shall be confined to the completion of the north jetty in accordance with the design and specifications of the Aransas Pass Harbor Company, and in continuation of the work heretofore carried out on said jetty by said company, and to such additional work as may be necessary for strengthening such part of the old Government jetty and any other hard material which may interfere with the formation of a channel by the natural action of the currents."

OBJECTIONS TO PRESENT FORM OF ITEM.

Under this provision of the House Bill the work is transferred to those who have persistently opposed it as of no value and who have predicted its failure, to be executed, with an amount not half large enough to complete, and with the probability that it may be expended in injuriously enlarging the dimensions without producing additional scour, with no responsibility for results and no limitations as to the time within which the work shall be commenced or completed. Neither is there any guarantee that the obstruction after Congress had directed its removal and made an appropriation therefor, will be sufficiently removed nor that the work will be prosecuted in such order as to produce scour instead of deposit, nor that the admission of the flood-tide upon which the scour depends will not be seriously restricted by the proposed sill embodied in the Government plan and constituting part of its north jetty, any or all of which would prove injurious if not disastrous to the Haupt plan and ultimately involve the further expenditure of more than $1,000,000 in a second jetty and for dredging and further sums for maintenance which are not provided for in this bill.

It is therefore proposed to request the Senate Committee on Commerce to accept Professor Haupt's proposition as being reasonable, safe, equitable and in the interest of the public service.

All of which fears have been fully confirmed by the subsequent expenditure, and the life of this patent has expired.

A PECULIAR WELL.

A member of the United States Geological Survey, engaged in making investigations of ground-water conditions in Ohio, reports that in Hamilton County, about half a mile south of New Burlington, there is a well which yields fresh and salt water at the same time. Except for the fact that two pumps are set in it side by side it resembles ordinary wells; but one of the pumps supplies water excellent to taste, while the water from the other is so highly charged with various mineral salts that it is almost brine. This water has been recommended by some physicians as having high medical value. When first dug, several years ago, the well was a great wonder to the people of the surrounding country, who flocked in great numbers to see it and taste its unusual water.

The secret of the phenomenon lies in the fact that two water-bearing beds confined between layers of limestone occur at this point, the upper carrying fresh water and the lower salt. The pipe of the fresh water pump is but sixteen feet long; that of the salt-water pump is thirty-five feet. The brine, being heavier than the fresh water, does not mix with it, but remains at the bottom of the well, and the longer pipe consequently draws only the salty water.

Section of Physics and Chemistry.

(Stated meeting held Thursday, November 21, 1907.)

The Corrosion of Steel.

By Allerton S. Cushman,

Assistant Director Office of Public Roads, United States Department of Agriculture.

Iron is unique among the elements, not only on account of the ease with which it dissolves or combines with nearly all other elements, but also on account of the changes in structure and physical character which are produced by the presence of almost infinitestimal quantities of impurities. A variation of a few tenths of one per cent. in the amount and condition of the carbon content may produce such a change in the physical properties of the metal, as to alter entirely its fitness for the various purposes to which it is put. A variation of a few hundredths of one per cent. of phosphorus in the specifications for certain useful forms of steel has been and still is a matter of controversy between interests representing hundreds of millions of dollars of capital and involving questions of the safeguarding of the lives and property of the public. Sulphur, silicon, and manganese are among the other well known elements whose presence or condition in extremely small amounts produces important differences in the character of steel. Absolutely pure iron has but a limited use in the industries of man, and as a rule the properties which are sought are produced by the presence of other elements.

This point is emphasized in order to call your attention to the fact that, chemically speaking, structural iron or steel is not a standard substance, but varies in composition and in character.

I have frequently called attention to the fact that resistance to corrosion was one of the most variable of the many characteristics of steel. That is to say, not only do the various kinds of merchantable iron and steel differ from each other within wide limits

in their resistance to corrosive influences, but specimens from the same mill or furnace will frequently show a great difference in this respect. There are few subjects at the present time more important to the engineer and the architect than the protection of structural steel from rapid, unsightly and dangerous corrosion. I wish to point out that there are two separate and distinct lines along which we may hope to make progress.

The first of these has to do with the understanding of the causes which promote corrosion and their elimination in the manufacture of the metal, and the second is the study of paint-films or waterproof coatings which shall really protect even the most inferior metals for indefinite periods. It is only the first phase of the subject that I shall consider to-night.

The tendency to oxidation is a characteristic inherent in iron, and an absolutely unrustable iron or steel will probably be impossible of accomplishment, even in the distant future. If, however, all the steel made resisted corrosion as well as the best of it, there would be no problem, and this paper would not have been written.

I shall not take your time this evening to review the older theories which were held to account for the rusting of iron, but will call your attention to the electrochemical or electrolytic explanation, which is now coming to be generally accepted. According to modern chemical theory, all reactions which take place in water solution are attended by certain readjustments of the electrical states of reacting particles which are called ions. You are undoubtedly aware that under the atomic theory molecules of compound substances are made up of atoms which are held together by a force or forces which represent large amounts of energy. Now, some substances, when they are dissolved in water, will conduct electricity, while others will not. The first class of substances which are generally inorganic acids, alkalies, and salts, we call electrolytes, while those organic bodies, such as sugar, which do not conduct electricity in solution, are non-electrolytes.

Arrhenius, a Swedish physicist, in 1887, announced the theory of electrolytic dissociation, the evidence for which can not be discussed here, but it can be said that the theory has been borne out by numerous researches, and is at the present time almost universally accepted. This theory tells us that the molecules of electro-

lytes, as they pass into solution in water, dissociate into ions which are simply atoms carrying, in spite of the smallness of their mass, very heavy charges of electricity. In order that no energy may be lost or gained, it follows that the dissociation must produce both positive and negative ions, which are equivalent and opposite. A rough analogy of what has taken place through dissociation is furnished by a coiled steel spring. If we put such a spring in tension and hold it thus, without addition or subtraction of material, we have impressed potential energy upon it, which will be returned in equivalent amount when by any means the tension is relieved. Indeed, we might consider one end of the spring as positive to the other end, and that in relieving the tension the energy reappeared by the neutralization of the positive and negative potentials.

To illustrate further what is meant by the theory of solutions, let us consider the system common salt and pure water. Common salt is composed of an atom of sodium combined with an atom of chlorine, and the molecule is represented by the simple chemical formula Na Cl. When sodium chloride is brought together with water it tends to go into solution, the molecules mingling with the molecules of the water, owing to a force known as solution pressure. As an increasing number of molecules appear in solution, however, a back pressure is exerted which to a constantly increasing extent resists the entrance of more molecules. This reverse action is known as osmotic pressure and it is perfectly clear that if an excess of salt is present the end of the action will come about for any definite temperature, just as soon as the osmotic pressure and the solution pressure are equal. But in addition to this the very important action takes place which has been just referred to. In passing into solution the salt dissociates into its constituent ions, which simply means that the solution forces tear apart the associated atoms and the energy which held them together appears in a potential form as equal and opposite charges of static electricity on the ions. So that the solution of salt in water is represented by the equation: $\mathrm{Na\ Cl} \longrightarrow \overset{+}{\mathrm{Na}} + \overset{-}{\mathrm{Cl}}$, in which $\overset{+}{\mathrm{Na}}$ and $\overset{-}{\mathrm{Cl}}$ represent the constituent ions. Osmotic pressure, however, acts against the dissociation pressure just as it does against the solution pressure, so that in concentrated solutions

we have a reverse action also taking place represented by the equation: $\overset{+}{\text{Na}} + \overset{-}{\text{Cl}} \longrightarrow \text{NaCl}$.

Chemists therefore say that the state of equilibrium for the system we are considering can be expressed by the reversible reaction:

$$\text{NaCl} \rightleftarrows \overset{+}{\text{Na}} + \overset{-}{\text{Cl}}.$$

Now, bearing these simple details of the modern theory of solution in mind we may return to the consideration of the reactions which take place when iron rusts. If a bright strip of iron is immersed in a solution of a copper salt, such as the sulphate, iron goes into solution and copper plates out on the iron. The reason for this is that the solution pressure of the iron is greater than that of the copper ions, therefore iron passes into solution, the positive static charge being transferred from the copper ions to the iron ions. This reaction is simply written:

$$\text{Fe} + \overset{+}{\text{Cu}} \,.\, \overset{-}{\text{SO}_4} = \overset{+}{\text{Fe}} \,.\, \overset{-}{\text{SO}_4} + \text{Cu}.$$

Now if we leave out the copper sulphate in this system, and immerse the strip of iron in plain water, a similar reaction takes place. It is known to chemists that even the purest water is to a slight extent dissociated, and therefore contains hydrogen ions. That is to say, while water consists mainly of molecules written H_2O, there also are present positive hydrogen ions $\overset{+}{\text{H}}$ and the equivalent negative hydroxyl ions $\overline{\text{OH}}$. Hydrogen acts as a metal and has a solution pressure somewhat less than that of iron. Therefore, when iron is by any means whatever brought into contact with water it will, to a certain extent, pass into solution by exchange with hydrogen. This reaction, upon which all forms of corrosion are primarily based, may be written:

$$\text{Fe} + 2\overset{+}{\text{H}} \,.\, \overset{-}{\text{OH}} = \overset{++}{\text{Fe}} \,.\, \overset{-}{\text{OH}} \,.\, \overset{-}{\text{OH}} + 2\text{H}$$

It has been shown experimentally that iron can not at ordinary temperature combined with oxygen unless the iron first passes into solution and it is apparent from this that the initial cause of rusting is not oxygen, but hydrogen bearing a static electrical charge, in other words, the hydrogen ion. Now all acids derive their character from the fact that they dissociate in solution with the production of hydrogen ions, and this is the reason why all acids stimulate the corrosion of iron. On the other hand, alkalies disso-

ciate in solution with the production of hydroxyl ions, which by the reverse action already explained neutralize and remove the hydrogen ions and thus inhibit rusting.

It is well known to engineers that sulphurous acid, as well as carbonic acid, from coal smoke produces rapid destruction of steel, whereas alkaline cements, mortars, and concretes will preserve steel imbedded in them so long as the reaction remains sufficiently alkaline. The only cases recorded in which steel is said to have corroded when imbedded in concrete, are those where percolating water under pressure has washed away the free lime and thus removed the alkaline reaction.

We may now turn to the role played by oxygen in the rusting of iron. Iron is one of those elements which exists in more than one state of combination with oxygen. The least oxidized state is called ferrous, while the higher state is called ferric. Oxygen always changes ferrous to ferric compounds. Iron, having once appeared in solution in the ferrous condition by exchange with hydrogen, is at once attacked by oxygen and precipitated at the point of attack in the form of the insoluble hydrated ferric oxide which is known as rust. This statement is easily proved by experiment, for all solutions of ferrous salts are directly oxidized or rusted by standing in the air. The role of oxygen is therefore secondary, but it is none the less important for the simple reason that by precipitating the insoluble rust the iron ions are destroyed and removed from solution, thus lowering the osmotic pressure and making room for more to be formed. The scientific explanation would be that the appearance and precipitation of the solid phase (rust) lowers the osmotic pressure, thus enabling the iron, driven by its solution pressure, to pass rapidly into the ionized condition.

To sum up, then, as far as we have gone, the rusting of iron is caused, first, by the solution of the metal by exchange with hydrogen, and secondly, by the action of oxygen on the dissolved portion, both actions being accompanied by a transfer and neutralization of electric charges on the reacting atoms or ions.

The next important point is that the solution of the iron does not, as rusting proceeds, take place uniformly over the exposed surface, but on the contrary the solution is stimulated at certain nodes or points and inhibited at others. To this direct local elec-

trolysis is due the peculiar form of corrosion known as pitting, which is almost always observed when iron and steel are deeply rusted.

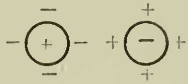
The fact that iron does not tend to go into solution uniformly and evenly all over the exposed surfaces, but passes rapidly into solution at certain surface points, can only be interpreted in one way; namely, that local electrolysis is taking place.

Now, applying what has already been said, it follows that as each iron ion appears in the solution a hydrogen ion must leave the system in order to maintain the equilibrium and so that no energy be lost or gained. It follows from this that hydroxyl ions must be left behind as the hydrogen changes into the gaseous form and disappears, so that we should expect to find a congregation of iron ions at one pole in the electric circuit and hydroxyl ions at the other. Owing to the formation, then, of these local electric couples, the surface should be protected at the negative poles around which the alkaline hydroxyl ions cluster, and attacked at the positive, where the iron is passing into solution, and being acted upon by oxygen.

Now, this action can be easily made visible as it takes place by means of a special indicator to which the writer has given the name ferroxyl. There is a certain reagent called potassium ferricyanide that forms a beautiful blue color, known as Turnbull's blue, when it comes into contact with ferrous ions. There is also an organic substance known as phenolphthalein which makes a rose-pink color with hydroxyl ions. Specimens of steel immersed in a solution of these mixed substances, and stiffened with agar agar jelly so that they cannot shake about, invariably show blue and red nodes, proving beyond all doubt the development of positive and negative nodes as corrosion proceeds.

Time will not allow of the presentation of a full discussion of the proofs that have been given to show that the corrosion of iron is always due to local electrolysis on the surface of the metal itself. The subject has been presented in detail in a bulletin recently issued by the Department of Agriculture. One of these demonstrations will, however, probably be of interest here.

When a section of rolled metal, such as sheet or plate, is immersed in water. if the electrolytic theory is correct, rusting must take place with the establishment of positive and negative spots or areas.

At the positive points iron will pass into solution and be rapidly oxidized to a loose, gummy, or so-called colloidal form of ferric hydroxide which is characteristic of rust formed under these conditions. It is a well known fact, as has been proved by experiment, that colloidal ferric hydroxide will move or migrate to the negative pole if subjected to electrolysis. We may therefore consider the possibility of two separate effects that may be produced, viz., when a positive center is surrounded by a negative area, and vice versa. These two conditions may be graphically represented by the two circles A and B: 

Now, as rusting proceeds we should expect in the case of A that the ferric hydroxide would be piled up in a crater formation, while the metal is eaten out at the center. In the case of B the effect would be reversed, and while the metal would be attacked in the surrounding area the hydroxide would be piled up in a cone at the center. That this is precisely what is taking place whenever a sheet of metal rusts under water a low-power microscope very clearly shows.

The photomicrographs in which the craters and cones are clearly shown have been published in the bulletin referred to above.

If you are willing to accept the electrolytic theory of corrosion you will very naturally inquire in what respect does it point the way to an improvement in the conditions as they exist at the present time. It follows from what has been said that the more carefully lack of homogeneity and bad segregation are guarded against during the processes of manufacture the less likely is the metal to suffer from rapid corrosion. If the iron contains metallic impurities dissolved in it, such as manganese, which differ electrochemically from iron, trouble is sure to ensue if there is a lack of homogeneity in the distribution of the impurity. In the old days when iron was made more slowly and received more careful working than is possible in the present day, serious corrosion was not the important problem it has since become.

The writer has in his possession a hand-forged nail, still in good condition, which was driven in the old Masonic Hall at Richmond, Virginia, in 1807, and for a long portion of

time has been freely exposed to the weather. There is a widespread opinion, which the writer shares, that the old wrought or puddled iron of thirty years ago is more resistant to corrosion than most of the modern steels.

But the interesting point is that modern steels vary so widely from each other. Here are two pieces of angle steel which constituted two members of a signal bridge on the Boston & Maine Railroad erected in 1894. These members were only six feet apart in the structure, and the conditions of environment, exposure and care were precisely similar, and yet one is corroded to the condition of lace work, while the other is hardly touched. The chemical and microscopical examinations of bright samples cut from these two specimens does not show any essential differences, both contain about 0.5 per cent. of manganese, and yet electrolysis has proceeded rapidly in one and almost not at all in the other. Does it not seem probable that the ingot, or portion of ingot, from which one of these members was rolled differed in segregation, or in chemical homogeneity, from the other? At all events, if all the members in this bridge structure had been as good as this best one, they would still be in service instead of on the table before you. It is of the utmost importance that we should learn to control the resistance to corrosion of structural steel, and to this end we should unite to urge upon manufacturers the necessity of making special efforts in this direction.

It would follow from the electrolytic theory that in order to have the highest resistance to corrosion a metal should either be as free as possible from certain impurities or should be by careful working and heat treatment rendered so homogeneous as not to retain localized positive and negative nodes for a long time without change.

Manganese is an element which is almost always associated in modern metallurgy with iron and steel, owing to the fact that this element is used as a flux in the great processes used to-day for changing cast iron into steel. Manganese, however, increases the electrical resistance of iron and as the percentage of this element, starting from zero, rises, the electrical resistance of the metal increases up to a certain specific maximum. Now, you will see, if the dissolving of manganese in iron raises the electrical resistance, that any changes in the equilibrium or distribution of the

manganese in the metal means that there will not be an even or homogeneous electrical conductivity throughout the mass.

If we have a metal in which the electrical conductivity for any reason varies from point to point on the surface we have the precise conditions which are necessary in order to establish the local nodes of electrolytic action on the surface which lead to rapid corrosion. It is apparent, therefore, that if we are to allow the presence in structural steel of comparatively high percentages of metallic impurities, such as manganese, we must attempt to obtain an extremely homogeneous distribution of such impurities. It is for this reason principally, in the opinion of the writer, that the more quickly and more carelessly the metal is manufactured and rolled, the more quickly it disintegrates under corrosive influences. As has been pointed out before, there are two methods of meeting the problem: first, to keep the percentage of metallic impurities as low as possible, and secondly, to guard against segregation and imperfect chemical homogeneity in the metal. In experiments we have made looking to the manufacture of a corrugated steel culvert for use in road building, it has been found by the author that corrugated metal, running as low as .04 manganese, has been more resistant to the corrosive test employed than the ordinary steel of the day, which usually carries about .5 per cent. manganese. Material of this kind has not been available for a sufficient length of time to determine whether under service conditions this low manganese metal will be longer lived, but it can safely be stated that the indications are all in its favor.

The writer has urged the manufacture of manganese-free steel for certain purposes, not because manganese is necessarily the cause of rapid corrosion, but because this impurity enables the metal to be rolled more easily and more cheaply, and in many cases permits the working in of large amounts of heterogeneous scrap. It is possible to manufacture shoddy steel as well as shoddy cloth, and though both of these materials have their legitimate uses for certain purposes, no one will claim for them high resistance to disintegrating influences. It is a hopeful sign of the times that manufacturers are beginning to pay serious attention to the manufacture of iron and steel for certain purposes which shall be to the highest possible degree rust proof.

Considerable attention has been given to the peculiarly passive

condition that can be induced on the surface of iron by contact with solutions of certain oxidizing agents. Without going into the details of this phenomenon, which have already been published, I will refer briefly to the peculiar action of chromic acid and its salts. Polished specimens of steel may be kept indefinitely without suffering corrosion when immersed in a dilute solution of potassium bichromate. On first thought it would seem a paradox that a strong oxidizing agent should have the effect of preventing the oxidation of iron, and yet this is the case.

According to the theory of the writer the oxidizing agent polarizes the surface of the iron to the condition of an oxygen electrode, so that it is immune from the attack of the hydrogen ions; thus the whole electrolytic process is checked or inhibited. A curious feature of this action is, that it is to a certain degree persistent after the metal has been removed from contact with the oxidizing solution, washed and wiped. This phase of the phenomenon requires further study, but at the present time it does not appear probable that the induced passive condition can be maintained on the surface to an extent that would make it of practical value for treating structural steel. With regard to the preservation of boiler tubes, and for certain special purposes it is not unlikely that a practical application of these principles will be found.

In conclusion it may be said that there is reason to hope that the time is not far distant when specifications may be drawn for material that is going into service under conditions which make it particularly subject to corrosive influences. The possible added cost of such specially resistant metal will be small in comparison to the benefits which will be derived from its use in the long run.

In a novel method of toughening metals lately introduced the metal to be treated is placed in a closed retort with a small quantity of mercury, says the London *Engineer*; the retort is subjected to pressure, and as it is heated to a point below melting temperature, a current of electricity is passed through the metal. Besides increased toughness, greater resistance to sea-water corrosion is imparted. The hardening is especially adapted for iron and steel, but is claimed to be useful for other metals.—*Eng. and Min. Jour.*

Mining and Metallurgical Section.

(Stated Meeting held Thursday, January 23, 1908.)

The Compression of Sèmi-Liquid Steel Ingots.

BY N. LILIENBERG.

The production of sound steel continues to be one of the most important questions of the present time. Previous efforts in that direction have mostly concerned special high-grade steel, but of late, even makers of structural steel and rails are looking for some suitable means of making ingots solid and of proper structure as well as of lessening the crop ends and segregation. In regard to rails, it has been conclusively demonstrated by experts (especially by the able engineer of the Philadelphia & Reading Railroad) that most of the failures in actual use, sometimes causing serious disasters, are due not to wrong chemical composition or of faulty heat treatment, but to treacherous cavities in the steel ingots, compressed by the rolling, but not welded. High authorities therefore now pronounce it very much to be recommended that even rail steel be compressed before the ingots are solid.

It is well known to be quite possible by any steel process to make sound steel without blow holes, the whole shrinkage then being taken up by the pipe which is correspondingly larger when other cavities are absent. In that case compression shows to greatest advantage, but even steel developing gases after being poured in the molds can be compressed solid, as I propose to show later on. It is only steel with surface blow holes which cannot be improved by compression.

The formation of pipe in steel ingots has recently been studied to considerable extent. Mr. Stead, in England, has published

very valuable observations, but it is especially Prof. H. Howe, in New York, who has gone deep into this matter. He shows that the formation of pipe is very complicated, because steel increases in volume at solidification and the sinking of the liquid steel then takes place at the different periods in accordance with the difference between swelling and shrinking of the interior and exterior. He has also by a series of experiments with melted stearic acid shown the influence of the temperature of the steel and of rapid and slow cooling on the formation of pipe.

I do not intend to discuss these matters here, as my object is to deal only with practical manipulation for improving steel. It is enough for practical work to know that pipe will more or less form in every steel ingot, no matter in what way it is cast. The advice to cast steel at certain desirable temperature is of course difficult to follow, besides this can never be completely executed, because the melted steel changes temperature between the casting of the first and the last ingots.

When steel has filled the mold there is instantly a thick crust of solid steel formed at the bottom and a thin crust on the sides enclosing a quantity of liquid steel. If the steel is allowed to cool undisturbed, the liquid mass inside gradually settles as solid steel in the inside of the shell, and as the quantity is not sufficient, owing to the contraction, a space is left extending from the top irregularly downward. If the ingot after being entirely solid and red hot is allowed to cool slowly without being worked, large crystals are formed, especially around the pipe, and there is danger that the internal strain may separate them and form fissures which afterwards may develop into large cracks.

This danger is again repeated when a cold unworked ingot is put into a heating furnace. An ingot allowed to cool slowly and undisturbed is made up of a surface of interlaced crystals and an interior of larger crystals of weaker cohesion. When, therefore, such an ingot, especially if it is of large size, is laid into a reheating furnace it is very difficult to prevent the surface from expanding more rapidly than the interior, which, therefore, is liable to break, sometimes with a perceptible sound. The cracks between the interior crystals are of course not visible, and there are cases when these have been enlarged by forging into considerable cavities, discovered when the finished article is machined, or still worse, not discovered until a break occurs.

It has been fully demonstrated that the steel crystals are larger in proportion to the length of time for solidification. Thereafter it depends on whether the substance binding the crystals together is strong enough to resist the internal strains during continued cooling. The whole steel industry may be characterized as "the struggle against crystals," and I therefore beg to emphasize the above said as being of equal importance with the obviation of pipe.

Segregation, depending on the floating upwards by the alloys of iron with lighter substances, can never be completely avoided but only lessened under special circumstances. These have been completely investigated by scientists, and it is not within the scope of the present paper to make a review of this matter. For practical purposes it is sufficient to remember that the longer the steel is kept liquid the greater opportunity is given for this separation to take place.

The defects to be overcome in steel ingots can thus be summed up as follows:

Coarse crystallinic structure in the interior.

Full sized pipe in sound steel.

Partial pipe and blow holes in steel where chemical action between carbon and ferrous oxide takes place in the molds.

Segregation.

A great deal of work and money has been spent on several methods for the purpose of preventing all this. Before discussing compression I consider it proper that other methods should be shortly reviewed, even if many of them are well known. I will therefore confine the observations to the work with the steel after it is poured in the molds, leaving out the phenomena in the melting furnace and ladle.

1. *Aluminum* thrown into molds acts on the upper part of the ingot, keeping it more evenly liquid, wherefore the diameter, but not the length, of the pipe, is lessened. It reduces ferrous oxide, thereby making the steel more quiet. But its action is confined to the upper part, and the lower is apt to have more cavities than otherwise. A larger quantity of aluminum is liable to be distributed in brittle spots all through the steel. The opinions as to the effect of aluminum on segregation seem to be divided.

2. *Casting continuous* ingots has been tried, but the practice has been largely abandoned. The apparatus is complicated, and as

the attachments to the cast ingots have to be removed, it can be used advantageously only for small ingots.

3. *Keeping the top uniformly hot* by placing a clay lined box on the top of the mold and applying a flame directed downward by blast through a coke fire is in successful operation, and a tolerably even sinking all over the section is thereby obtained. The apparatus is, however, complicated and must consume a considerable amount of coke, especially if a greater number of large sized ingots have to be treated simultaneously. The lining of the box will of course have to be kept at the melting point of the steel. When the operation stops the remaining liquid steel will continue to sink somewhat before solidification. The action can only extend to a limited depth, and thus cavities are liable to form in the lower pasty part of the steel. As the steel is kept liquid a longer time it is difficult to see how coarse crystals and segregation can be avoided .

4. *Casting with the large end upward.* The pipe is generally composed of one upper visible cavity ending with a thin bottom, below which another pipe stretches irregularly downwards to an undefined length with a point, or with a series of scattered cavities. This is the case in the ordinary tapered molds standing on loose bottoms with the small ends upwards. In casting with wide end upwards the pipe is generally confined to the upper visible sinking and the long stretched appendix under the bottom is absent, which is so far an advantage. This is now the prevailing method in Sweden. A clay lined box is placed on the top of the wide end of the mold, whereby the pipe is still further lessened. In most cases it does not stretch below the upper wide end of the ingot, which, however, cannot always be entirely relied on. Between the box and the mold the clay lining is so shaped as to create a neck in the steel which facilitates the subsequent striking off of the head. It is obvious that all casting with the wide end upwards tends to increase the formation of coarse crystals, but on the other hand the wider end receives more working in subsequent rolling. The method gives good results in Sweden, where high-priced steel is produced and where consequently the corresponding expenses can be borne. These consist in handling the molds by turning them upside down to get out the ingots, forming and drying the sink boxes, striking off and remelting the sink heads. If American manufacturers making medium-sized ingots

in stationary casting pit will bear the above-named expenses in making high-grade steel I offer my assistance in putting the process in operation, as I have recently personally witnessed its successful use in Sweden.

With a view of taking advantage of the shorter pipe when the wide end is turned upwards for such heavy ingots that it would be impracticable to turn the molds upside down after casting the following plan has been suggested. The small end is provided with a loose conical bottom, fitting closely into the recess. After solidification the mold is placed over a hydraulic ram, which forces bottom and ingot upward out of the molds, which is held down by two upright stationary bars shaped as hooks on the upper end.

5. *Centrifugal* force acts favorably in driving out blow holes, but can of course not obviate the pipe. Machines to that effect are, however, too unwieldy to come into general use. The molds will then have to be suspended on trunnions in the circumference of a horizontal revolving wheel. (In connection with this I beg to mention that I have built a machine for making hollow ingots by rotating the circular molds each separately in vertical position around its axle. The apparatus is more simple and the removal and replacing of molds easier than in previous attempts in that direction.)

I hope that this review has given sufficient reasons why the above named methods cannot come into general use for the largest quantities of heavy ingots, especially those which are cast standing on trucks. The only way to treat these is by *compression* of the *semi-liquid steel.* When properly executed such procedure will make the ingot free from interior blow holes and pipe, improve the structure by making the interior crystals smaller, thereby also lessening the subsequent work on the solid ingot, and reducing the segregation. To be effective the compression will, however, have to be timed according to the solidification. It must commence as soon as possible after casting and be continued as long as any liquid steel remains in the interior. If it commences too late the pipe has already been covered with oxide and is thus impossible to completely efface. If finished too early some liquid steel will remain and continue to form pipe. In several compression methods the inventors have lost view of these points. I have stated above that even steel developing gases in the mold can be compressed solid provided these gases do not appear close

to the sides. The following changes then take place. The first zone of occluded gases is closed up. Then a new quantity of gases in the liquid interior near the center is set free. If the compression stops there it has only moved the blow holes further inward, but if it is continued as long as liquid steel remains even this secondary blow holes will be closed up.

I have here below presented a review of the principal methods of compression which have been, or are tried in practical use.

1. *Compression from the top* has not gained any ground. It is obviously impossible to close up the pipe in that way, considering that the solid walls of the upper part of the ingot cannot well be compressed lengthways. Besides the gases are given no opportunity to escape.

2. *Compression from the bottom* is in successful operation at some works in France and England. The steel is then forced upwards into a conical mold, which the inventor compares to wire drawing, the top being left open. The bottom of the mold is of course loose and supported by a piston. The apparatus is here represented. The casting is done in a place separate from the press, and the ingots and molds are then transported together over a plunger which forces the loose bottom upwards together with the steel. The mold has of course to be strong enough, and is therefore preferably round or octagon, and it must be heavily banded. As the ingot gets firmly stuck in the mold another plunger from the top forces the ingot loose from the mold after the operation is finished. But this plunger is lifted up during the compression so as to leave the top open. This works well and economically when it comes to making a few large ingots, such as for heavy guns, shafting, etc. An apparatus of a similar principle is erected at a steel works in the country making heavy ingots for guns where the whole charge is emptied into the mold. Ingots made in this way are sound, free from cavities, of proper uniform structure, and the segregation is diminished. But if, for instance, a fifty-ton charge divided among twenty ingots shall be treated in this way the problem becomes complicated. As each ingot has to be pressed during a sufficiently long time it is obviously impossible to treat one ingot at the time in the same press, but a sufficient number of presses will have to be in operation simultaneously with correspondingly high expenses of installation. The attendance will also be expensive, as it is impossible

for one man to watch over the whole row of ingots, that they are worked properly. The molds will be very expensive and heavy to handle. It would be still more difficult to apply this system for the large quantities of steel cast on trucks.

3. *Compression from the side in the molds.* The constructions made on this principle must of course have divided molds. The two halves are separated by a short space as soon as a skin is formed sufficiently strong to hold the liquid interior during the compression. The results are quite satisfactory as far as improvement of the ingot is concerned. The following two constructions of this kind are worthy of mention:

(A.) The casting is done while the two halves of the mold are kept together by a hydraulic ram. When the solid skin of the ingot is strong enough the mold is opened sufficiently for introduced a plate as long as the ingot, after which the halves are forced together again by hydraulic pressure. The liquid interior is thereby forced to keep the mold filled to the top until the ingot is solid. By making the plate in section as a segment of a circle the sides of the ingot are not compressed. Such machines give good results, but can only be used for small sized ingots.

(B.) For heavier ingots the following construction is made: The halves of the molds are separated by two bars cross shaped in section and held together by a hydraulic ram during the casting. As soon as a skin sufficiently thick is formed the cross shaped bars are drawn up leaving the empty space between the edges of the molds. The hydraulic ram then slowly forces the molds together, thus giving the necessary pressure. This procedure gives very good results and is in continued practical operation. It can also be used for treating ingots standing on trucks. The obstacle in the way of a general adoption of this method are, however, that the molds of the steel makers will have to be changed from the ordinary solid tapered ones to straight divided.

That the handling of the divided molds is expensive.

That the walls will have to be made extra strong at the base if they shall stand the swelling of the steel during compression, thereby making the molds heavy and expensive.

That the expense is further increased by the edges having to be planed.

That it is difficult to avoid a fin where the skin folds in the

space between the edges (which fins are planed off by a machine on the cold ingots, a procedure obviously unsuitable for a large and rapid production).

4. *Compression from the side on the bare ingots stripped of the molds.* In this way many of the above-named difficulties are avoided, besides the molds will last longer as not being in contact so long with the hot steel and liable to be pressed out of shape. The first question is whether it is possible to strip the ingots early enough. The time of solidification stands in proportion to the weight and size of the ingot. An 18″ square ingot weighing about 2 1/2 tons will require about one hour to get solid to the center. The stripping of such ingots usually takes place about thirty minutes after casting. Although this is somewhat late, liquid compression can still be done at that time, but it is preferable to reduce this to fifteen minutes. Experience has shown that this can be done at steel works, where the casting and stripping is managed properly. The taper of the molds should of course be sufficient and the inside of them smooth. One single small cavity, crack, or remaining scrap of steel may prevent the mold from slipping off the ingot. It is also desirable for early stripping that the stopper in the stripping machine is square instead of as usual, round, so as to enable it to get supported by the solid crust of the ingot while the usual round stopper is liable to sink down. It is even doubtful whether a stripping machine is beneficial for the ingots. The surface is so weak that it does not require much pulling force to produce surface cracks if the ingot sticks to the mold. It is therefore preferable for early stripping to have such a taper on the molds and so smooth inside surface that the molds can be lifted off by the ordinary travelling crane, especially as the work can then be made more rapidly by lifting several molds at the time. Ingots with a thin solid crust and liquid inside can obviously not be handled very much on account of the danger of the surface breaking.

The methods proposed of compressed early stripped steel ingots are mainly the three following ones: (A) *Rolling* the ingot in vertical position between four slowly revolving rollers. This would be theoretically the ideal compression, but it is very difficult to carry out for the reasons, *that* the ingots get out of shape between the rollers; *that* they cannot be easily grasped and handled in semi-liquid state; *that* the machine is not only complicated, but

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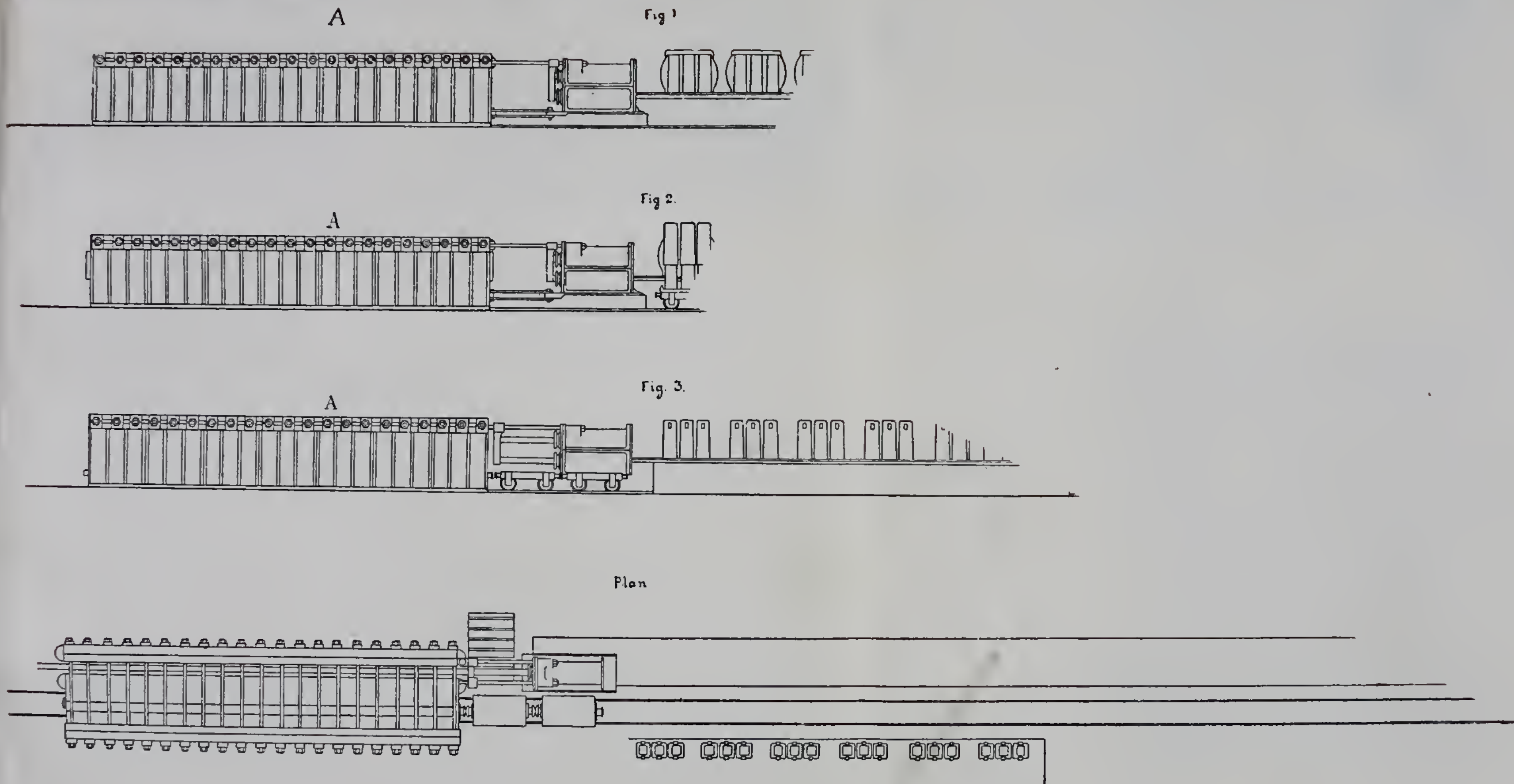


PLATE I. Continuous press for steel ingots cast on cars.

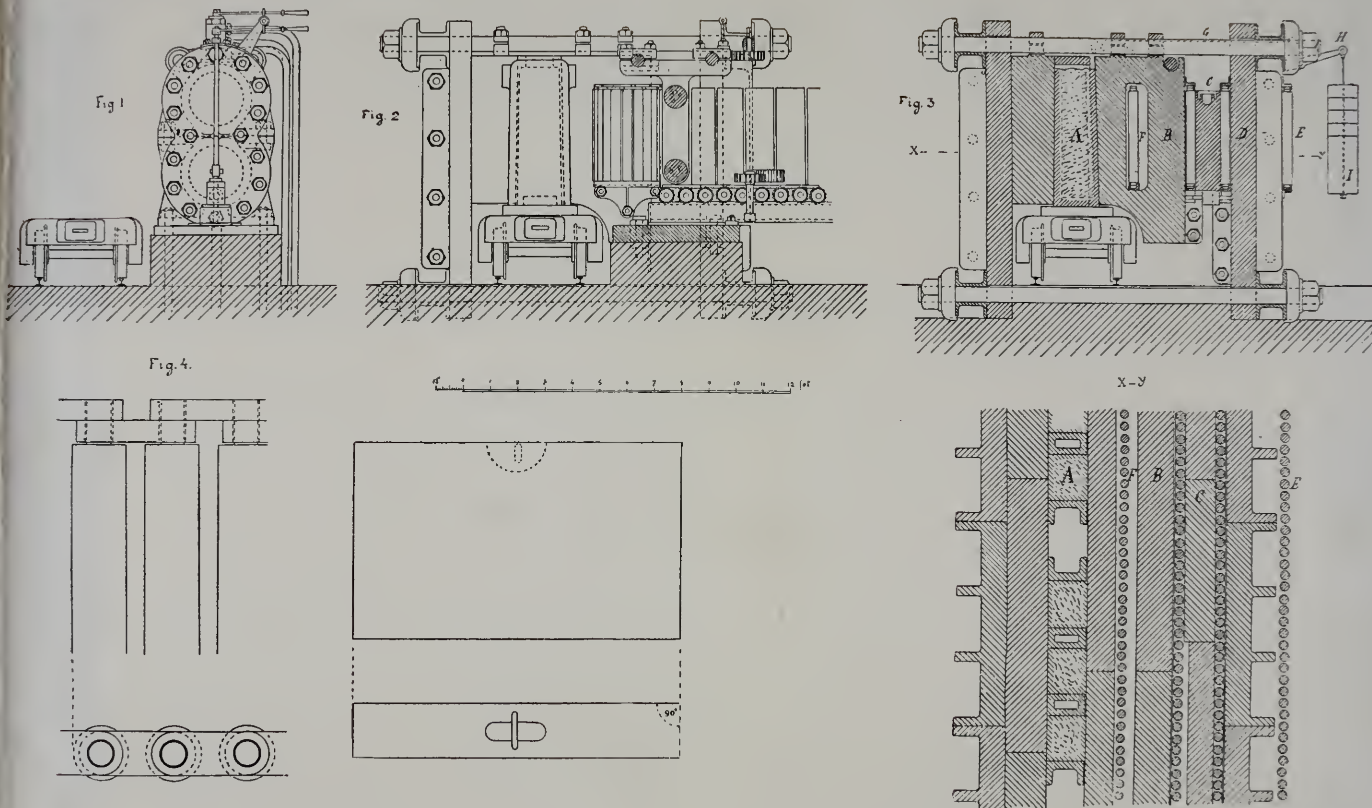


PLATE 2. Continuous press for steel ingots cast on cars.

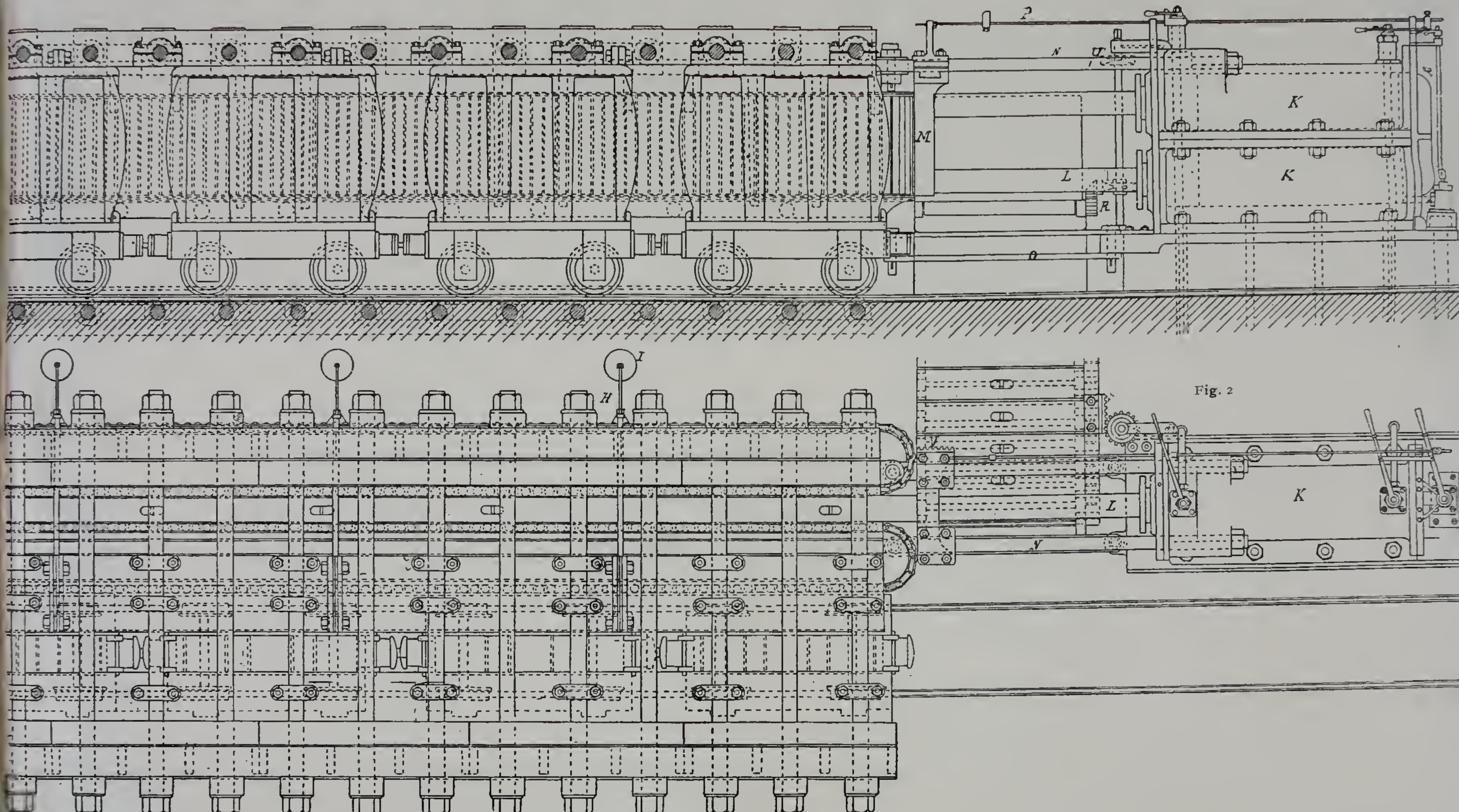


PLATE 3. Continuous press for steel ingots cast on cars.

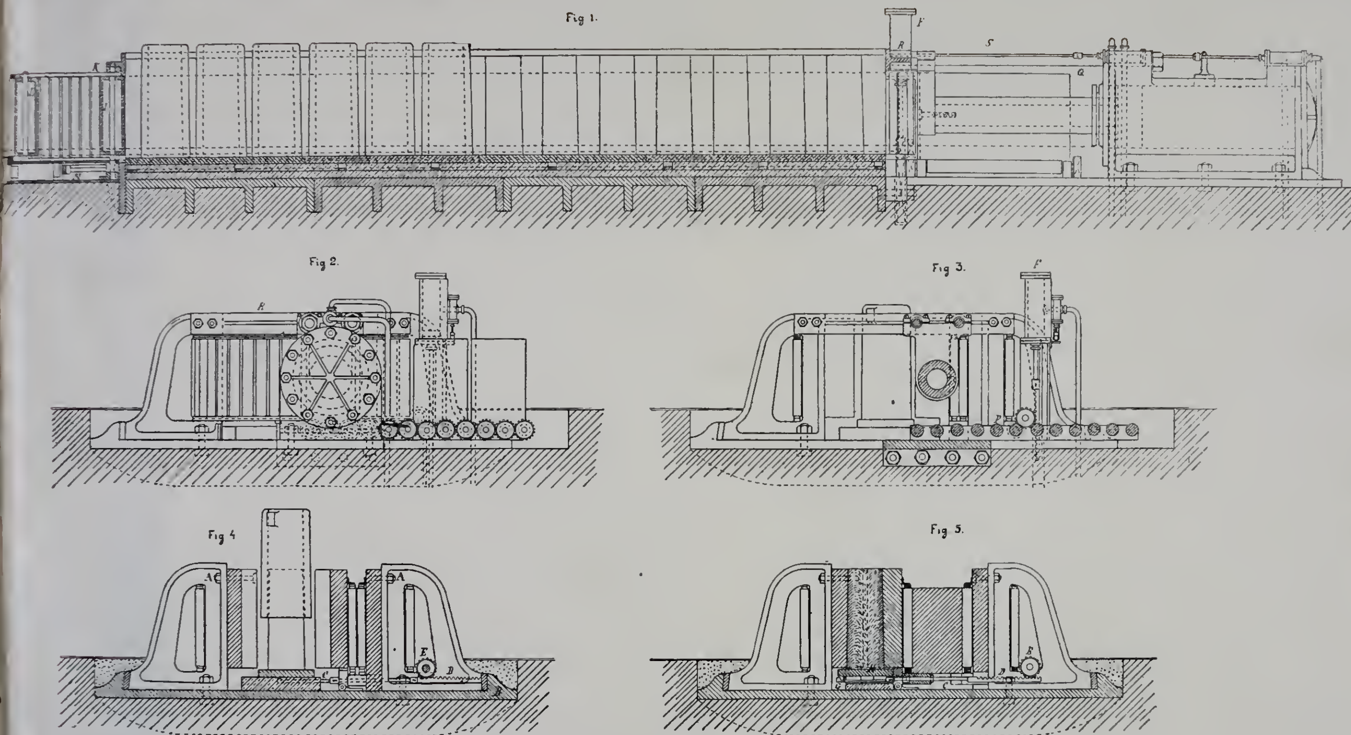


PLATE 4. Continnous press for steel ingots cast in pit.

Fig. 1

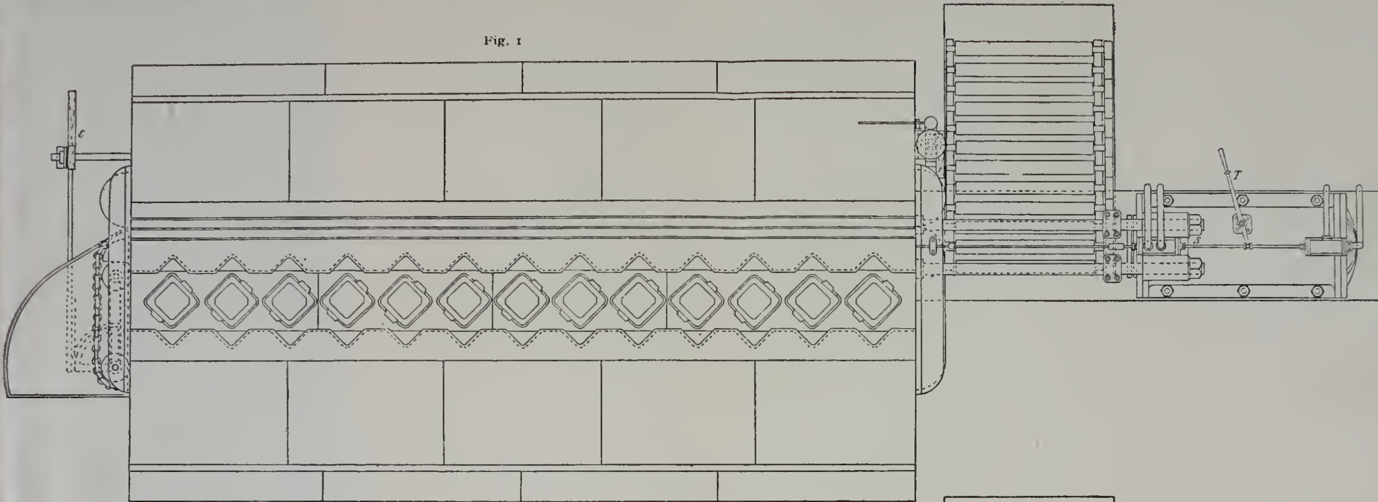


Fig. 2

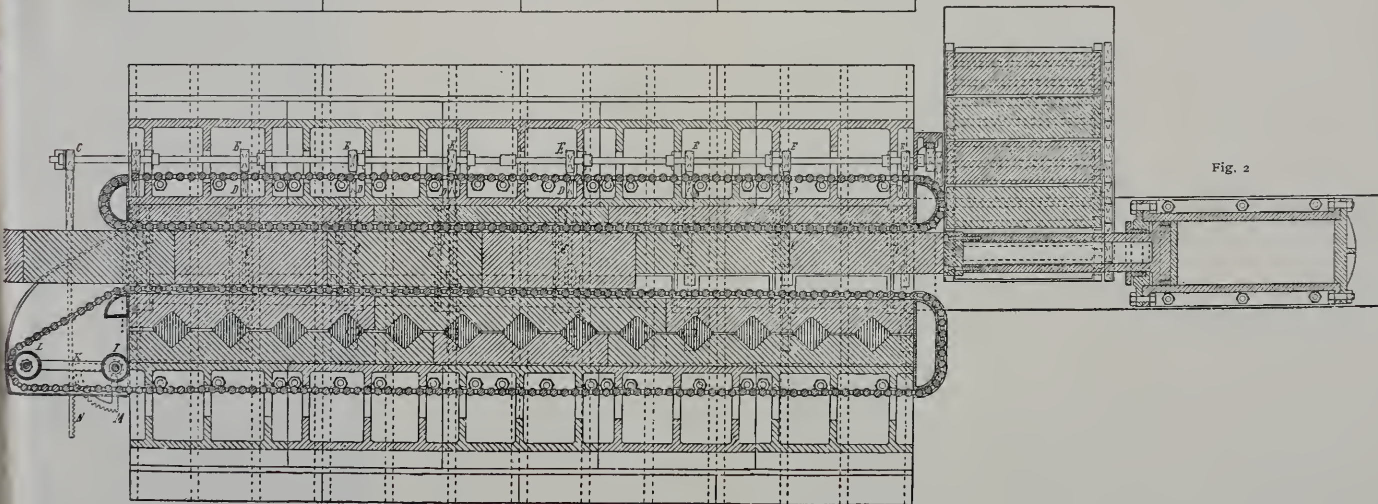


PLATE 5. Continuous press for steel ingots cast in pit.

there will have to be a great number of them, as one ingot cannot be treated at the time, because the following would then cool off.

(B) *Placing the stripped ingot* in a corner and working on it from two sides by hydraulic rams, after which it is allowed to fall through the bottom and be carried away. This works all right with one ingot, provided it really can be transported into the corner in its weak state. But the compression will have to be continued during the whole period of solidification and consequently the following ingots will get cold before the first one is finished. It would therefore be necessary to have a great number of hydraulic cylinders for compressing all ingots at the same time, which would be very expensive, both in construction and manipulation. Besides, it would be impossible to apply this system on the largest quantities cast on trucks.

(C) *Leaving the stripped ingots standing* where they are and act on the whole row simultaneously with a battery of hydraulic rams placed side by side, the whole of course being surrounded by a sufficiently strong frame. In this way the compression can of course be prolonged during the whole period of solidification and lifting the semi-liquid ingots is avoided.

It therefore seems that this could be used for ingots while standing on trucks. In carrying out this process we however meet with several great difficulties. The ingots will have to be moved a small distance sideways so as to release them and in case of casting on wheels to enable the locomotive to pull out the train without delay. This lateral movement should be made by the returning stroke of the hydraulic rams, but such machinery will not be easy to construct for a whole of ingots, especially considering that of the mold and trucks must be made free and clear from all constructions in one moment when the train shall be pulled out. If the ingots are pressed on the sides they will have to be caught in pressing between the projecting sides to take up the side swelling. The ingots will then get jammed in and an undue time and labor will be consumed in getting them out. This is of course avoided by pressing them diagonally, but placing the molds with the diagonals on the center line of the trucks, makes the whole train longer.

Such a whole battery of many hydraulic cylinders will be very expensive in construction. Each set of cylinders will have to be

regulated separately, as the first cast ingot having less heat than the last cast will have to be finished earlier. The finishing pressure on the steel will have to be about two tons per square inch. 18″ square ingot 60″ high, presenting a side area of 1080 square inches, requires 2160 tons final pressure assuming a water pressure of 2000 pounds per square inch in the total piston area of the hydraulic rams for each ingot will be 1210 square inches. There should of course be two hydraulic cylinders, one on top of the other, for each ingot, that is 605 square inches corresponding to 28″ in diameter. For a charge of twenty-five tons divided on ten ingots the number of hydraulic machines would therefore be twenty. If these ingots are standing on five cars to the total length of the train is about 32′, and the hydraulic cylinders with wall thickness and flanges placed side by side stretch out to about 36′. The center of each ram will have to point to the center line of the corresponding ingot. This may be somewhat difficult to adjust by only a locomotive pulling the train, and probably an additional adjusting apparatus would have to be made. The ingots are generally grouped two on each truck, close together, and therefore the corresponding hydraulic cylinder should also approach each other. The distance between the centers of two 18″ ingots placed on a truck is about 27″ while the centers of the 28″ hydraulic cylinders cannot be less than 35″, even if they are cast together. It may therefore be desirable to press each group of two ingots by only two hydraulic rams placed on top of each other, thus making the total number ten. The piston area of each will then be 1210 square inches and the diameter 3′ 11″. Such unusually large cylinders if made of cast-steel would have about $4\frac{3}{4}$″ wall thickness to resist the pressure of 2000 pounds per square inch. For a charge of fifty tons of course ten pairs of such large cylinders would be needed. The cylinders must not be laid too close to the ingots as otherwise the pistons may swell from the heat, the contact being extended over a long period. Therefore the width of the apparatus will make the apparatus occupy a large floor space. The pressure continued during the whole period of solidification will have to be modified according to the different stages. This is almost impossible to do by hand for a large number of hydraulic, especially on a small stroke of a few inches. The movement is then liable to be done by jerks with the consequence that the liquid steel is thrown out violently

and corresponding stratas and layers be formed in the ingot. It is thinkable that the valves could be moved by wormwheels, but as said before the speed has to vary at different periods and the pistons working at the first cast ingots should finish their work so much earlier than the last cast as the difference in time of casting. Such an automatic apparatus would therefore present a rather complicated mechanical problem.

From the above said, it thus seems as if there is no method for making solid ingots which is suitable for the largest quantities of medium size, especially for those cast on cars. At the same time, the desire is as great as ever before to lessen the waste and crop ends to obtain the proper and reliable structure of the steel with less rolling and forging than at present, and also to lessen the segregation. The question then forces itself on us. Is it possible to accomplish this in a practical and sufficiently economical way? Looking over the requirements again we find them standing as follows:

1. The casting should be made without changing the ordinary solid tapered molds but the ingots stripped earlier than usual, which can be done.

2. The stripped ingots should not be removed from their places on the bottom until the compression is finished.

3. In order that the pressure may be continued according to the solidification, all the ingots will have to be pressed simultaneously, but they must be finished at different periods, according to the difference in heat between the preceding and following ingots.

4. This should arrange itself automatically without any special attendance and the work of hauling, etc., should be reduced to a minimum.

5. The installation should be sufficiently simple and not occupy too large space in a steel works.

To all appearance there is only one way to accomplish this:

Leaving the early stripped ingots standing inside of a framework, pressing the whole row of them simultaneously by a wall moved forward by driving in wedge blocks. As the construction is patented, I hereby give some details.

Pressing the Stripped Ingots While Standing on Trucks. The drawings Nos. 1, 2, 3, represent the case of a forty-ton charge divided between eighteen ingots 18″ square, 60″ high, weighing about 2¼ tons each.

On the drawing No. 1, Fig. 1, shows the press (A) and the ingot train (B) during casting. The molds can remain the same as they are now, but the bottoms should be made so as to extend whole under each group of molds. As early as practicable after casting the ingots are stripped. For this purpose it is desirable that the taper of the molds as well as their inside condition is such that the stripping can be done by ordinary plunger. For this size of ingot the stripping should be done not later than fifteen minutes after casting when a crust is found sufficient to hold the liquid interior.

On the drawing No. 1, Fig. 2, represents the train (B) moved nearer towards the press (A) and with the stripped ingots. Three ingots are placed on each car although the number is generally two. On each group of ingots have been placed *frames of cast-iron* (D) filling up the space between the ingots and the outside plates provided with ridges are inserted by the lower end between the ingots and flanges on the bottom plate. These frames are simple to make, and as they do not need to be lifted to the full height of the ingots but can be shoved in sideways, the placing in position of these six groups of frames by travelling crane will only take a few minutes. No special care need to be taken to get them in exact position sideways, because the press will afterwards take care of that. These frames serve the following purposes:

1. To keep the ingots from falling when the stand stripped on the moving cars unsupported by the molds.

2. To take up the side pressure during the compression. This side pressure from the swelling would be equal to the front pressure if it were the question of treating an entirely liquid substance, but the solid outside steel makes it here only a part of the front pressure growing smaller in proportion to the solid steel increasing in thickness.

The frames are left on the ingots until the train has departed from the press and reached the soaking pit, where they are easily taken out at the same time with lifting the ingots. The width of the frames is so much less than the width of the ingots as the amount of pressure, which in this case would be about three inches. The stripped ingots standing on the train are immediately backed up by the locomotive so as to enter the press, as shown on drawing No. 1, Fig. 3. No special care need be exer-

cised to get the ingots in exact position in the press, as it is only needed that all of them are inside the apparatus.

The drawings Nos. 2 and 3 show the installation and operation of the machine.

On the cross section Fig. 3 (No. 2) the ingot (A) is shown as caught between the two walls. The movable piece (B) is pressed by the wedge block (C) being forced in between the stationary wall (D) and the movable one (B).

Roller bearings are placed between the wedge blocks and the walls, as otherwise an extravagant expenditure of force would be needed. These are made very simply of solid rolled steel with the ends set off and inserted into links, as shown on Fig. 4 (No. 2.) The link chains turn around half-round surfaces on each end of the press, as shown on the plan on drawing No. 2. The returning idle parts of these link chains and roller bearings move the one outside the fixed wall, the other inside a cavity in the movable wall, as shown at (E) and (F) (Nos. 2 and 3). The links holding the rollers slide between channel irons fixed to the walls. The lower of these contains steel balls on which the links can roll. It should be remembered that the movement will be so slow as about $\frac{3}{4}''$ per second, and that therefore these roller bearings do not have many of the inconveniences attendant to ordinary rapid roller bearings. The wear is of course comparatively small, also the inclination to tilt, which in roller bearings is more apparent in conical than in cylindrical rollers. To steady them against tilting, if such should appear, the chain can be made to contain plates at a few points having rollers inserted and made like hinges to bend around the ends. These link chains present the advantage over other roller bearings that they can be inspected during the open passage around the ends, and it is easy during the slow movement to exchange any broken or worn part.

The *wedge blocks* are in this case 6′ long, 3′ 9″ high. The ends stand at right angles to the side gliding against the fixed wall and the opposite side is tapered. As the time of compression is about twice the time of casting, the first cast ingot placed in the front end of the press should be only half pressed through when the lastly cast ingot at the other end begins to be pressed. With a compression of 3″ the tapering of the wedge blocks should therefore be $1\frac{1}{2}''$ on the blocks moving in the press at the same time, that is about $\frac{1}{8}''$ per 6′ length. Beginning with a thickness

of 12″ the last end of the blocks should therefore be 15″. It is easy to make the total slanting surface of the blocks slightly curved so that the pressure is automatically changed according to the different periods of solidification. The wedge blocks should preferably be made of steel and planed on all sides, but if this should be too expensive, some good cast-iron chilled on the two long sides can be used. As the blocks are driven out from the press they are taken care of by the travelling crane, returning them in groups to their position as indicated in No. 3, Fig. 2. This is the only actual handling during the operation. It is obvious that machinery could be constructed for returning the idle blocks, but there seems to be no need of this additional complication, as the travelling crane generally is at leisure during the compression. The blocks stand on rollers ready to be fed in before the hydraulic rams one by one by a simple mechanism. The rollers are connected by cog wheels and by a rack with slanting teeth, which is moved back and forth from two corresponding cog wheels (T) and (U) fixed on a vertical shaft. The upper of these cog wheels engages in a short rack fixed on the cross head of the hydraulic piston rods. It is thus apparent that the movement of the pistons feed in the blocks automatically into position for the next forward stroke. The last wedge block is driven forward by blocks with parallel sides leaving a clearance space of 3″. When all the wedge blocks are driven out the movable wall is thus released and can be moved backward.

The release is then effected automatically by draw-bars (G) hooked on the top of the movable wall. These bars are connected with levers (H) on which the weights (I) hang.

The Hydraulic Compressor is composed of two cylinders (K) and pistons (L), which in this case have a stroke of 7′. The piston rods are 10″ in diameter, which is somewhat more than is needed for the strength in order to reduce the consumption of water at the returning stroke. The front ends are screwed to a cross head (M) which is guided by sliding on the bolts (N) which connect the cylinders with the press. The valves are here made as revolving discs, but can of course just as well be piston valves if this should be preferable. As the returning stroke must be made quickly in order to save time, the corresponding outlets should be made larger than the inlets and a separate exhaust valve is therefore placed at the lowest point at the rear end of the cyl-

inders. The movements of the valves are automatical by connecting them with a sliding bar (P) provided with lugs which are pushed by the movement of the cross head.

The construction of this machine is not difficult to execute and it does not contain more movable parts than several appliances in a steel works (for charging, etc.). It is evident that the automatic movements reduce the attendance, and this consists in fact only by the work of one machinist in regulating the hydraulic pressure and looking at the proper movements of all parts. It is the only machine in which all the ingots are finished automatically in order according to their solidification.

Calculations are made in this case as follows. The information of the resistance of steel from about one-half ton per square inch semi-liquid until about thirty tons to eighty tons when cold (depending on the carbon) is rather meagre. It is desirable that in the present case the final pressure should be about two tons per square inch. This is provided that the front of the ingots are cast convex and pressed flat. The surface of the ingots in this case is 18″ x 60″ = 1080 square inches requiring 2160 tons. The total pressure on eighteen ingots will thus be 38,830 tons. The net power to move the wedge blocks lengthways will be obtained by multiplying with the taper and dividing with the length, that is $\frac{38{,}830 \times 3 \text{ in.}}{2 \times 52 \text{ ft.} \times 12 \text{ in.}}$ = about 93 tons. To this has to be added the pressure for overcoming the friction. If the wedge block were moving direct between two surfaces this would be $2 \times 0.10 \times 38{,}830$ tons = 7,776 tons, but the 4″ rollers reduce this to $\frac{1}{4}$ (2 x 0022 x 38,830) = 428 tons, that is 856 tons for both sides. The total power would then be 856 + 93 = 949, to which 50 tons ought to be added for extra frictions and work, making the total 1000 tons. The hydraulic pistons are here 24″, total area 904 square inches, and maximum water pressure would then be $\frac{1000 \times 2240}{904}$ = 2500 pounds per square inch. The volume of water needed for one forward stroke is here 3.14 sq. ft. x 7 x 2 = about 44 cu. ft., and for the return stroke 3.14 — 0.54 = 2.6 sq. ft. x 7 x 2 = about 36.5, which makes totally for a double stroke 80.5 cu. ft. This being repeated twenty times, the volume of water is 1610 cu. ft. By multiplying the volume of water with the pressure, the mechanical labor is gotten. As the maximum pressure of 2500 pounds per square inch is only needed towards the end of the operation the medium water pressure can be put at 1500

pounds per square inch. The total amount of labor will then be 1500 x 144 x 1610 = 347,760,000 pound feet, and assuming a period of compression of 45 minutes, the mechanical labor per second will be 128,800 pounds feet, which divided by 600 gives 214 horse power net for the hydraulic pump.

The cost of construction and installation is difficult to obtain even approximately, especially as the prices per pound vary according to the work made on different pieces. At request I have, however, made the following estimate for a machine treating twenty tons divided on ten ingots 17″ square 55″ high, standing on five cars, the train occupying a length of thirty-two feet.

THE FRAME WORK.

10 stationary ridged plates of cast iron	373,700 lbs.		
1 stationary wall near the ingots	212,460 lbs.		
1 movable wall	232,420 lbs.		
	818,580 lbs. at 2c	$16,370	
28 bolts 5-½″x15′	33,240 lbs. at 3c	997	
56 nuts	13,380 lbs. at 6c	800	
56 cross pieces under the nuts	13,475 lbs. at 2c	270	
8 channel irons	34,315 lbs. at 2½c	85	
20 bearings for the movable wall	9,030 lbs. at 6c	540	
			$19,835

THE PRESSING APPARATUS.

15 wedge blocks 6′x3′9″x13″	172,090 lbs. at 3c	$5,160	
375 rollers of cold rolled steel 4″x42″	56,250 lbs. at 3.5c	1,970	
Lins for do	9,730 lbs. at 6c	584	
Channel steel	7,060 lbs. at 2.5c	175	
Other appliances		470	
			$ 8,359
FEEDING APPARATUS FOR RETURNING BLOCKS.			600
FRAMES AROUND THE STRIPPED INGOTS,	31,505 lbs. at 3c		945

HYDRAULIC PRESS.

2 cylinders 24″ diam. 6′ stroke	35,955 lbs. at 6c	$2,156	
2 piston rods	5,490 lbs. at 6c	329	
2 pistons	2,820 lbs. at 6c	329	
Valves		200	
1 cross head	1,500 lbs. at 6c	90	
Connecting bolts		275	
Bottom plates		200	
			3,420
Total			$33,159

PRESSING THE STRIPPED INGOTS WHILE STANDING IN A CASTING PIT.

The same principle as previously described is applied to this case but the construction of the machine has to be different as illustrated in the drawings Nos. 4 and 5.

The case selected for illustration is a 10-ton charge divided on thirteen 12″ ingots. As the stripped ingots must not be removed the casting-pit will have to be contained in the press and sufficient space given for lifting the molds, handling the ingots, changing the bottoms, and getting down into the pit for cleaning. The distance between the movable and the fixed wall will therefore have to be greater than in the previous case and the movement of the movable wall back and forth will have to be made by special machinery before the pressure with the wedges is applied.

The frame is composed of castings (A) sufficiently strong to take up the pressure and bolted to the bottom plate (B), which is ribbed so as to resist the breaking strain. This arrangement is made necessary because the top of the casting pit cannot be obstructed by transversal bolts tying the two sides together.

The apparatus for moving the wall laterally before compressing and after the operation is finished consists of bolts (C), which are to be seen on the section plan No. 5, Fig. 2, and on the transversal sections No. 4, Figs. 4 and 5. These bolts are connected with racks (D), moved by pinions (E), which are mounted on a shaft running the whole length of the machine. On the fore-end of this shaft a cog wheel is moved by a vertical rack which is pushed up and down by a hydraulic piston in the cylinder (F).

The side pressure of the ingots is taken up by placing them diagonally and arranging the grooves in the pressing walls accordingly. The pressure is therefore done obliquely on two sides and the ingots are released without extra work after the pressure. As stated above this construction could not be applied to ingots standing on the cars. The bottom for the molds stands on a layer of fire-bricks in which grooves are taken up so that the lower part of the projections in the movable wall can move forward sufficiently to shove the stripped ingots into the recesses before compression begins, all of which movements are illustrated by Figs. 4 and 5, drawing No. 4. After the compression the mov-

able wall is drawn backward half of the free space before the hooks (G) catch into the projections (H) on the under side of the bottom plates, after which these plates with the whole row of pressed ingots are simultaneously drawn backward and the ingots after pressing will thus stand in the middle of the casting pit ready for removal. On both sides of the bottom plates and the foundation of fire bricks there are two gutters into which dirt can be scraped and rinsed out from the end.

The wedges will, as in the preceding case, have to form a length together equal to the double length of the apparatus for the reason as stated above, that the first cast ingot should be about half compressed when the lastly cast is beginning to be worked on. These wedges will have to be so thick as to fill up the whole space, that is, considerably larger than in the preceding case. They are driven out by blocks with parallel sides which leave a clearance space, all of which is shown in the horizontal section Drawing No. 4, Fig. 2. These last named blocks will have to be lifted up and removed from the apparatus by travelling crane before the movable wall can be drawn back.

The roller bearings are moved by chains as in the preceding case and the returning empty chains move inside of the fixed walls as plainly indicated on the sections of the drawings. When the movable wall is shoved towards the fixed one this chain gets slack. For the purpose of keeping it in order the following apparatus is constructed at the rear end of the machine, as indicated on the Figs. 1 and 2, Drawing No. 5, and on the Fig. 1, Draw. 4. A shaft carries a cylinder (I) and two arms (K) which are bolted to another cylinder (L). When these arms swing out 90° the roller bearing chain is lengthened correspondingly and the slack taken up. This movement is effected by the cogsector (M), which is worked on by the rack (N) connected with the bar at the other end of which another rack is moved by the cog wheel (O) placed at the end of the shaft.

The transversal motion of the sections of wedge blocks for feeding them into the press at each stroke is made by placing them on rollers (P), see Figs. 2 and 3, Draw. 4. These rollers move in bearings contained in two transversal beams, as indicated. The front end of the tops of these rollers are connected by cog wheels. Only every other of these are keyed on the tops and

those between them are running loose. By thus giving away the movement of the half number of the rollers the simultaneous motion can be imparted by a less number of cog wheels. The rear end of one of the rollers nearest to the vertical cylinder (F) is provided with a cog wheel which is moved by another cog wheel counted on the main shaft close to the vertical rack. By a special clutch the cog wheel can be connected or disconnected with the roller. It will thus be seen that the vertical hydraulic apparatus is used for feeding the wedge block forward when it has finished moving the walls for pressure. It is obvious that another clutch will have to disconnect the vertical rack from the main shaft during the time when the apparatus is used to move the blocks side ways.

The cylinder for moving the blocks forward contains in this case only one ram, as the heighth is smaller than in the preceding case. The piston of this ram is of larger size than needed for the strength in order to save the volume of pressure water during the backward stroke. The cross-head is guided by the two bolts (Q), which also serve to tie the upper part of the cylinder to the transversal beam (R), which is bolted to the frame of the press. On the upper side of the cylinder are located two systems of balanced cylinder valves moved by a rod (S). At the end of the forward stroke the cross-head strikes against a lug fixed on this side and thus moves the valve and causes the returning stroke automatically. The openings in the valves are so arranged that the returning motion is more rapid than the forward. At the end of the back stroke the movement can be made either automatically by the cross-head striking against another lug, or by the hand lever (T), which in this case probably would be preferable.

Calculations: As above stated a 10-ton charge divided on thirteen 12″ ingots is here selected as illustration. The diagonal width of one ingot is 17″ and the length being 48″, the area presented for pressure of one ingot will be $17'' \times 48'' = 816$ sq. in. At the final pressure of 2 ton per sq. in. and on thirteen ingots will then be $816 \times 13 \times 2 = 21216$ tons. It is presumed that a pressure of $2\frac{1}{2}''$ is sufficient. The length of the press is 30′ 6″ and the double length therefor 61′. The new power required for moving the wedge blocks will therefore be $\frac{21216 \text{ x } 25}{61 \text{ x } 12}$ = about 72 tons. The friction in the roller bearings will according to the formula stated in the preceding part be equal to $\frac{2 \text{ x } 0.022 \text{ x } 21216}{4}$ =

233 tons, and therefore on both sides of the wedge blocks $2 \times 233 = 466$ tons. The total end pressure will therefore have to be $466 + 72 = 538$ tons. Adding different friction we will make this even 600 tons. The diameter of the hydraulic cylinder is 30″ corresponding to an area of 706.86 sq. in. By dividing this into the total pressure in lbs., viz. 600×2240, the water pressure required per sq. in. will be about 1900 lbs. With this pressure given the product obtained by multiplication with the length and number of strokes will give the total expenditure in lbs. ft. and this divided by the time and with 600 lb. ft. per second will give the net amount of horse power required by the hydraulic pump.

In order to demonstrate the formation of pipe I have experimented with melting different materials and found that paraffine most closely resembles steel in its solidification. I have therefore made the model here exhibited in which a charge of paraffine ingots can be seen compressed as described above. It is also easy in this way to see the difference if compressing too early or too late which I can here show with samples.

Betz Building, Philadelphia, Pa., Dec., 1907.

MONEY STRINGENCY IN CANADA.

While there is no apparent slackening of trade in Canada, its activity is being reined in by the financial stringency. That is to say, the demand for merchandise of all kinds keeps up, but the expansion which other conditions would appear to warrant is not going on at its former rate, owing to lack of funds. In every part of the country confidence is in as good tone as ever, and many concerns would enlarge their works and add to their equipment if only the money were forthcoming for such expansions. The point should be emphasized that, whereas tightness of money is not uncommonly due to mistrust of trade conditions, in Canada's case it is attributable to abounding faith in the trade conditions. The great volume of trade has, so to speak, sapped up all the available money, and there is no margin for continuing the onward movement at the same rate. Every bank has now more good customers than it can keep supplied, and therefore has to curtail the accommodation it gives to each, advising many that for the present they must positively give up new capital projects and continue on their existing scale of operation. For a manufacturer to turn out as much product this year as his works produced last year more money is required, for the prices of material are higher, and in many cases so is the rate of wages.—*Iron Age.*

ELECTRICAL SECTION.

(Stated meeting held Thursday, December 5, 1907.)

Process and Apparatus for the Production of Carbon Bi-Sulphide in the Electric Furnace.

By Edward R. Taylor.

The application of electricity is fast revolutionizing many industries, and perhaps no other field is more inviting for this revolution than the chemical.

Many reactions require heat for their accomplishment, and also the materials of the reaction to be kept apart from combustion reactions and products. Retorts and crucibles have served for these separations, and are made of many different materials, oftentimes very expensive. Even this is not their worst defect. All are limited in size, and when it comes to a large production of any product so manufactured, it can only be had by multiplying these small retorts or crucibles.

Again, except in the case of platinum or other expensive materials, the life of these retorts or crucibles is very short, for they are subject both to the corrosion of the materials within them and the intense heat to which they must be subjected, to bring about the required reaction.

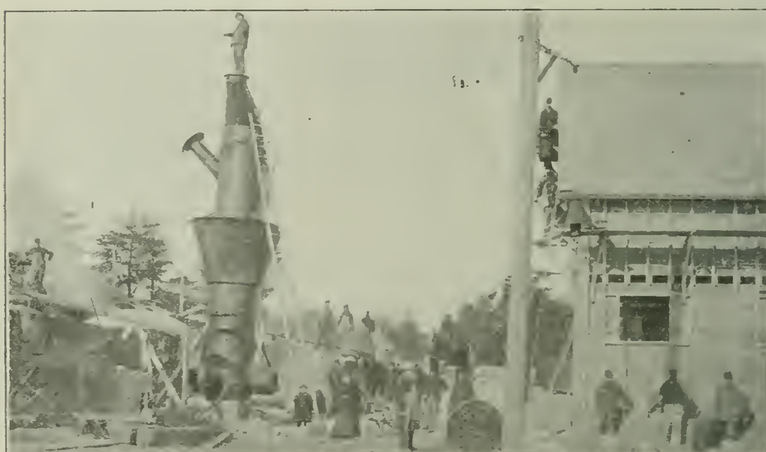
Oftentimes their cleaning is very troublesome and expensive. They are generally bad conductors of heat, and last and by no means least, they constitute a very wasteful application of heat.

From a manufacturer's point of view, their greatest defect is their limited size which leads to the multiplication of these retorts or crucibles for any larger production of goods. There is probably no one in all the past who has been obliged to use these who has not racked his brain for some way—I was going to say, out

of them. Well, let it stand—it probably conveys my meaning, if it is not strictly literal.

Being in the manufacture of bi-sulphide of carbon, which in retorts is one of the most disagreeable of all our manufactures, I, too, racked my brain, and am glad to say that I succeeded in racking it to good purpose. As I see it now, it seems to me peculiarly fortunate that this particular production should have been one of the first to get out of the retort. This feature will have our attention further on.

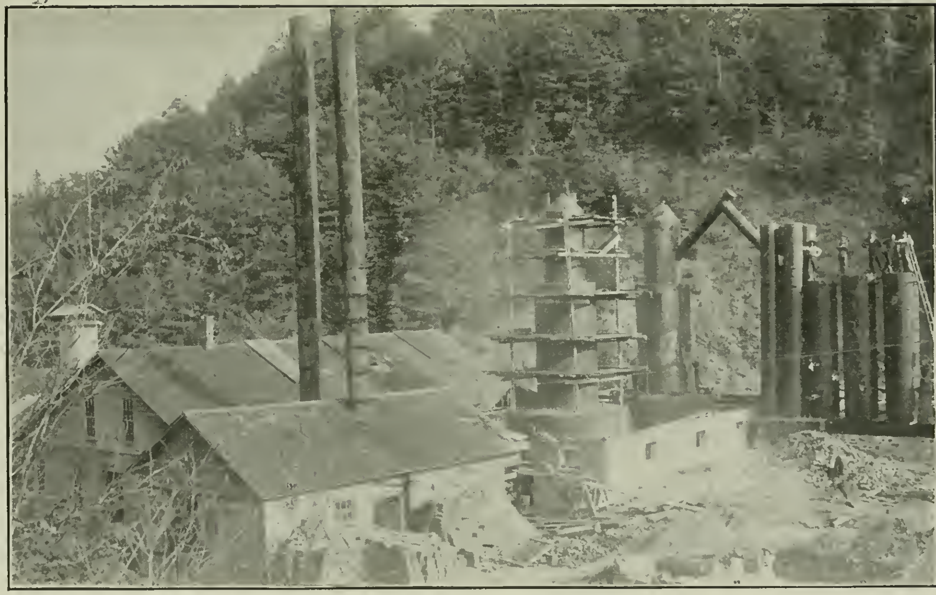
My first demonstration was made in Pittsburgh, in 1893,



First furnace 4 ft. diameter and 23 ft. high.

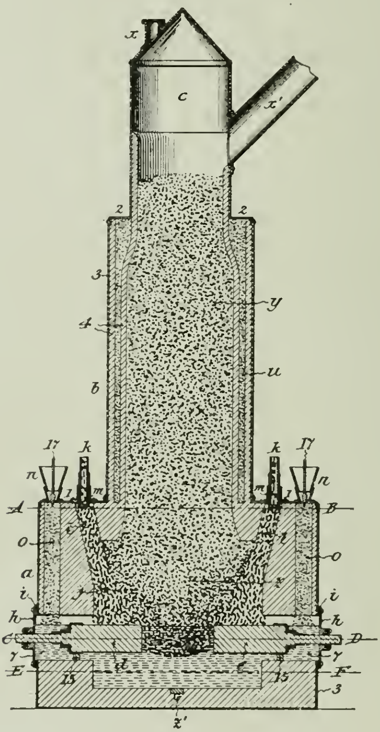
through the courtesy of our lamented Captain Alfred E. Hunt, of the Pittsburgh Reduction Company.

The first furnace for the industrial production of bi-sulphide of carbon was four feet in diameter and twenty-three feet high. It is illustrated here in the blue print and also by the lantern slide. Four feet in diameter was much smaller than my best judgment dictated, as I felt the heat would be too intense, and it did not afford sufficient room for the movement of the material. A vindication of this conviction came early. The sulphur was melted in the surrounding jacket, and while being hindered one time in feeding sulphur, the heat became intense and soon spoiled the shell of the furnace. Fortunately there was on the ground a



16 ft. x 41 ft. furnaces during construction.

still seven feet high and ten feet in diameter, and I at once determined to cut off the furnace, after supporting the upper part, and substitute this still for the lower part of the furnace. A large door and part of the side wall of the building had to be removed to get it into position. We were soon in shape again. That was a grand move and we had room in which to do something. While this enlargement was a great advance over the



Showing electrodes and chimneys for reinforcing with broken carbons.

previous construction, we being able to make about 5,000 pounds per day with 100 horse power, we could run it but four or five weeks till it had to be shut down, cleaned out and electrodes renewed. This usually required three weeks, including time for it to cool off. This was money expense without income. The demonstration of the larger furnace was so overwhelmingly successful that the next construction was made sixteen feet in di-

ameter and forty-one feet high. This is the size of the furnaces now in use, and they have more than confirmed the advantages anticipated for them. We can run these furnaces more than a year before renewing the electrodes or cleaning out.

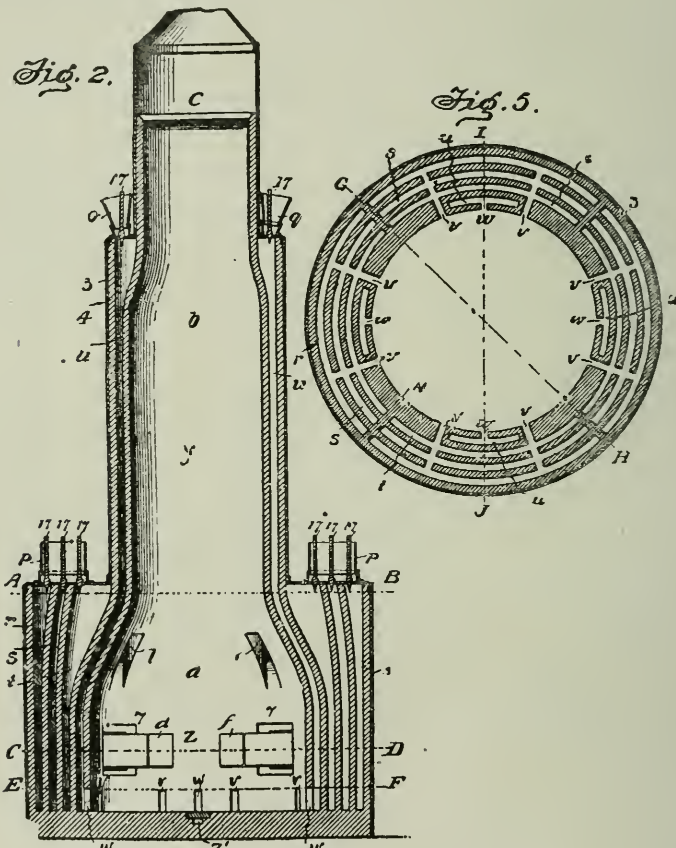
Each composite electrode in this furnace is composed of twenty-five carbons each 4″ x 4″ x 48″ making a complete electrode twenty inches square and forty-eight inches long. We use two phase alternating current and four of these electrodes. In the center of the furnace they are about twelve inches apart. Chimneys above each of these electrodes are used to convey broken carbons down upon them and over their ends. Their action breaks up and diffuses the current, which instead of being of one or two arcs, is broken up into a multitude of little ones, but these probably disappear as the furnace heats up. This moderates the intensity of the heat, stops entirely the hissing of the current, so common in arc furnaces, and protects from excessive wear the main and more expensive electrodes, taking, so to speak, the brunt of the battle.

They also, if possible, serve a still more important purpose in regulating the current and saving the necessity of moving the electrodes through the walls of the furnace, which would be a very troublesome thing to do in a furnace filled with melted and vaporizing sulphur. This was a problem that presented very serious features in the early thought of a furnace for this purpose. The broken carbons also relieve the intense violence of the heat at the terminals. It will be appreciated that for low temperature work, like the manufacture of bi-sulphide of carbon, this is very essential. They also facilitate the starting and stopping of the furnace. Indeed the broken carbons are so valuable in this respect that we find we can stop and start at will, even when the furnace has become completely cold, and I cannot emphasize too highly the value of these broken carbons in a furnace of this construction.

By reason of these considerations, no furnace is more capable of abuse without harm than this. There is no noise, no violence, no sudden fluctuations in the passage of the current, and it never refuses to go.

Aluminum bars 6″ wide and ⅝″ thick (shown in the lantern slide), connect the insulated electrodes with the two Stanley in-

ductive type dynamos, which are of three hundred and thirty kilowatts capacity each, and usually run by water power, but we have an engine to help out in times of low water. The voltage varies between forty and sixty, according to conditions in the furnace, but there are no sudden fluctuations in voltage and the average is about fifty volts.



Showing electrodes and channels in the periphony for sulphur.

To charge the furnace sulphur is filled in up to the top of the electrodes and broken carbons are added, including the filling of the different chimneys over the several electrodes and the shaft of the furnace is filled with charcoal, and the periphery spaces of the furnace filled up with sulphur.

With the larger construction it is easy to feed the cold and crushed sulphur around the periphery of the furnace, allowing it to find its way in the melted state into the interior heat zone.

Being progressively raised in temperature as it approaches the zone of reaction, the level of the melted sulphur is regulated by the amount of current supplied to the furnace and the amount of cold sulphur fed into the periphery.

On combination of the sulphur vapor with the charcoal, the formed bi-sulphide of carbon rises through the charcoal above it, heating it as it progresses downward towards the reaction zone.

Thus in this furnace, the heat seeking to escape by radiation, is continuously borne back to the reaction zone by the incoming material.

So complete is this return, that when making bi-sulphide of carbon at the rate of fourteen thousand pounds per twenty-four hours with the room at 16°C. the outside shell of the furnace shows temperatures at different points ranging from twenty-three to sixty-four degrees as a maximum. With yet more power in the furnace, the production would be greater and these readings still lower.

This brings us back to a point referred to before, with reference to this particular production for this demonstration of the conservation of heat in the electric furnace.

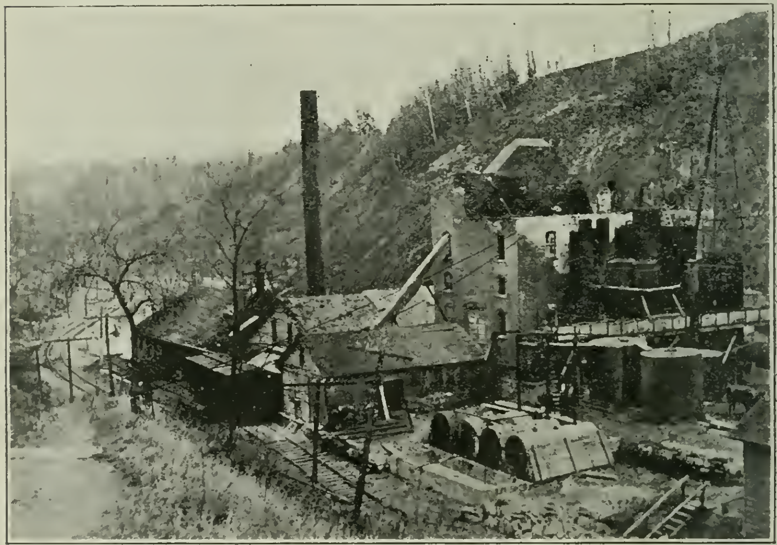
The low melting point of sulphur very much facilitates the development of this idea, and to my mind it is difficult to overestimate the value of this return of heat to the zone of reaction.

My ideal for an electric furnace is one where the outer shell of the furnace is merely a jacket as cold as the surrounding atmosphere and mainly serving to keep gases from escaping, and to direct the flow of the interior materials, the real walls of the furnace being one or more of the reacting materials completely surrounding the reaction zone, and continuously bearing back to the inside heat as constantly endeavoring to escape.

Graphically it may be represented by, say an egg-shaped interior, surrounded with reacting material constantly approaching and returning heat that has escaped from the hot zone, but cannot make its way out of the furnace itself, thus using the heat produced for the definite reaction in hand; this incoming material being of such thickness as to completely absorb all radiant heat.

It is now well demonstrated that this is easily brought about in case of material not too difficultly fusible, and one need not hesitate to work this principle on materials having a melting point very much higher than that of sulphur, which as we have seen behaves most admirably, for in this with sufficient power we could carry almost to perfection the ideal conditions above indicated.

No form of combustion can really compass these conditions, but this is made possible by this form of electric furnace. A correct balance of power to the size of furnace and materials used, is the key to this ideal result. It is obvious that this principle is of



Completed works, showing railroad facilities, stills for refining storage tanks, etc.

wide application and without doubt will be in the future largely applied.

In most electric furnaces the gases have been of secondary or of no consideration. But not so with the manufacture of bi-sulphide of carbon. It is gaseous in the furnace as formed and it is the thing we are after. We may therefore follow it out of the furnace through the pipe at the top and on to the condenser, shown in the lantern slide of the works in construction, after which it is refined for market by distillation. The stills for this

purpose are shown in the foreground of lantern slide of the works after completion.

It is obvious that any gaseous product from such a furnace can also be saved and utilized even should it be a by-product and not a main product, as in this case; as for example carbonic oxide, which could well be used in gas engines. For such use it would be much more valuable than producer or blast-furnace gas, as it is not diluted with nitrogen.

The bi-sulphide of carbon being an endothermic compound absorbs heat in its formation, and being in the vapor state at its formation also has its latent heat of vaporization with it, as also the high temperature of its formation. These actions are constantly taking heat away from the heat zone, and as noted, distributing it to the charcoal coming down and to the sulphur coming in from the bottom and the sides. By these means a comparatively uniform temperature in the reaction zone similar to the uniform temperature of a liquid when it has reached its boiling point is maintained. Thus the work balances itself. There are no sudden fluctuations of current in the furnace except the fluctuations of power outside of it.

For other reactions and other products a different temperature would be the normal one just the same as different liquids maintain their boiling points. This uniformity of temperature, very low or very high, may be continuously maintained for months at a time.

Nothing cold ever reaches the heat zone of this furnace. Sulphur or charcoal completely envelopes the heat zone. With the continued progress of the charcoal and the sulphur towards the heat zone there is the continual increment of heat, so that when they do reach the interior of the furnace both are at a bright red heat, the charcoal in a glow—and the sulphur in a state of vapor. The combination is immediate and the compound hurries upward, heating the charcoal in its path, being pushed on irresistibly by the material behind it.

We can modify the conductivity of the furnace by the feeding of broken carbons and by the height at which we carry the melted sulphur. Indeed we can completely cut off the flow of current through the furnace by allowing the melted sulphur to raise sufficiently high above the terminals. So the maintenance of a suita-

ble level of melted sulphur is an important factor in the operation.

So easy is it to maintain these necessary conditions that my man in charge takes great delight in running it. Often he says to me, "I have no words to describe how nice and easy this furnace runs. It is rest to run it. It is like driving a gentle horse. It is a great satisfaction to run it. No trouble here. It is just pleasure. This furnace is just grand." He even exhibits affection for it when he says "this dear furnace." Thus I am greeted with expressions of pleasure day after day. Think of the maker of bi-sulphide of carbon evincing such satisfaction with his work as this. I venture the assertion that no other process of manufacture of bi-sulphide of carbon calls from the man who runs it any such expressions of pleasure.

In Sicily I saw a plant where they used forty-eight retorts for making 10,000 pounds of bi-sulphide of carbon in twenty-four hours, and required thirty-five men to run them. When you consider that every few days these retorts had to be opened from the top and the ashes spooned out, sulphurous acid coming up into the faces of the men, you can imagine how disagreeable it is to attend to such retorts, every individual one of which must have more attention than an electric furnace making more goods than the whole of them. We appreciate things by contrast.

This blue print illustrates the retorts formerly used by me in this manufacture. The opening at the bottom shows where we removed the ashes from the bottom of them every ten days or two weeks. This was done while they were hot, lost us about twelve hours in time and was very disagreeable, but nothing to compare with spooning them out as just referred to in the Sicily works.

With the electric furnace the cleaning out is done with a cold furnace about once a year with no trouble or inconvenience.

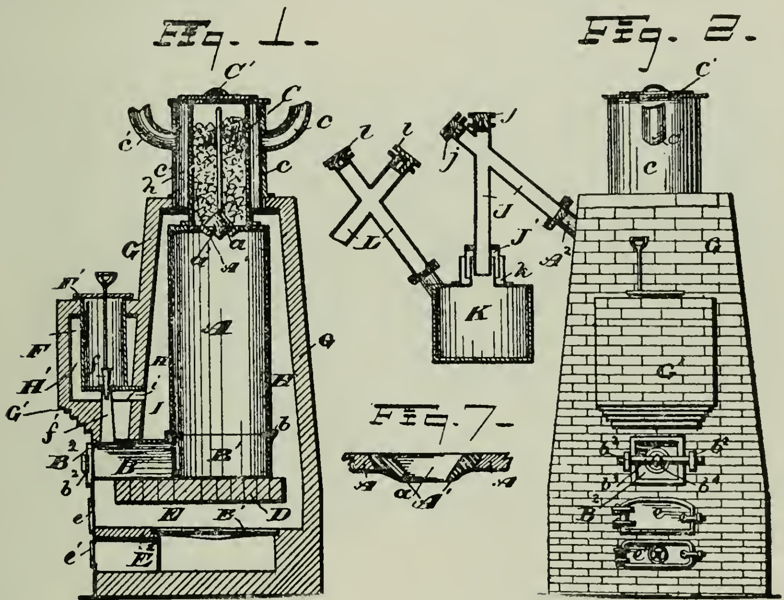
Just at this writing a telephone from the works saying, "Oh, it is fine, Mr. Taylor!" "You really do not take the comfort with these furnaces that I do."

This reminds me to say that we transformed an old paper mill into this chemical works—but the name "mill" will not leave it, so it comes to pass that I have the unique distinction of having a "chemical mill," whatever that may be.

When the furnace is in full operation, the charcoal is supplied through an opening at the top of the furnace to a hopper above a

bell similar to those used in blast furnaces. As often as there is room in the shaft below the bell the charger (holding about thirty-two bushels), is dumped and the charger refilled. In this place it becomes more or less heated, so it does not enter the furnace absolutely cold. A very strong endeavor was made to substitute coke for charcoal three years ago, but it was a failure and abandoned.

In like manner the sulphur is fed into the periphery from the hoppers above them, as often as is necessary to maintain the best working conditions, and it is very desirable that these conditions



Retorts formerly used for making bi-sulphide of carbon.

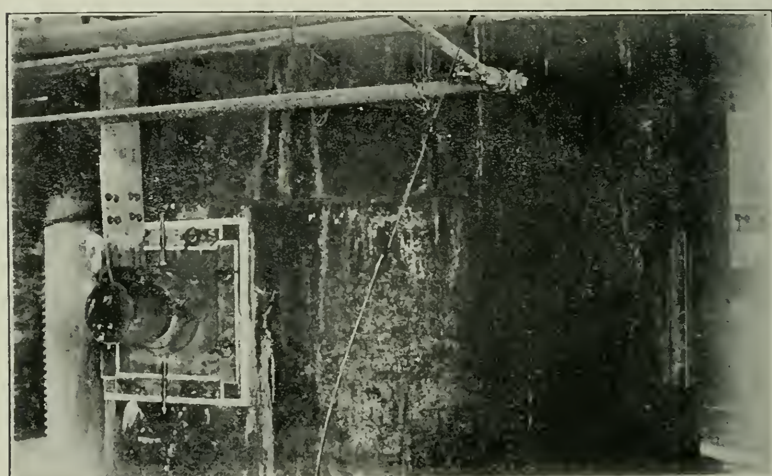
should be such as to keep these spaces full.

If the power is equal to the capacity of the furnace for producing goods, sulphur should be put in whenever there is room for it under all conditions.

As we are now working we can produce 14,000 pounds per twenty-four hours in one of these furnaces, but in so doing we are not able to keep the periphery of the furnace completely filled with sulphur to the top, which would be the ideal condition, had we sufficient power. This size of furnace is quite capable of pro-

ducing 25,000 pounds per twenty-four hours. It would be very interesting to note the temperature of the shell of the furnace with such a production. We always find the larger the production the more economical and the cooler the shell.

If on a production of 14,000 pounds the highest temperature of the shell is 64°C., may we not expect that on a production of 25,000 pounds in the same furnace we may closely approach the ideal condition of having the outer shell at a temperature but little, if any, exceeding the temperature of the surrounding air? Is it not a condition devoutly to be wished and is this not in a direction in which we may ultimately expect success?



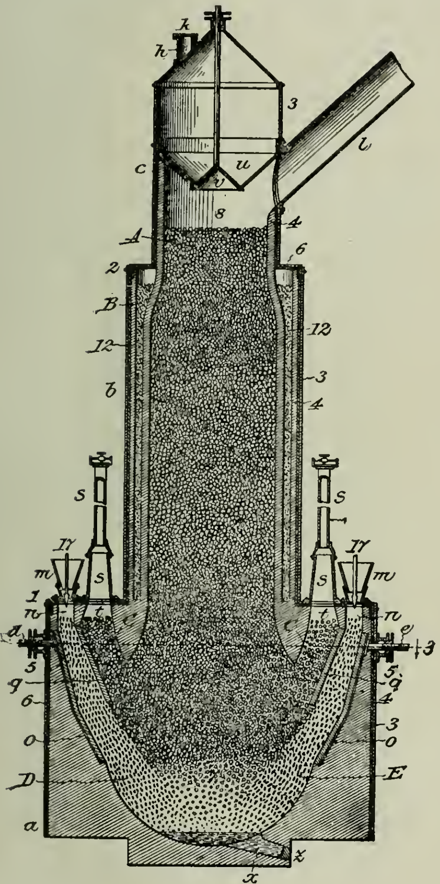
Showing electrode with packing gland-aluminum attachment, and insulated plate attached to furnace.

It may be interesting to trace the different intermediate connections between the carbon electrodes and the aluminum bars outside of the furnace.

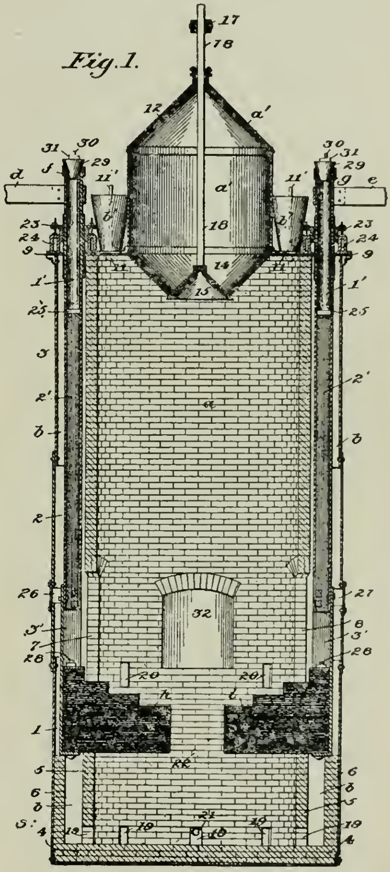
We have in this blue print shown a socket of iron into which the carbons are inserted,—another cylindrical casting attached to this socket passing out of the furnace through a plate insulated from the shell of the furnace and through a packing gland similar to that of the piston of an engine. This is made large and is packed with mica and asbestos paper. This is done so carefully and is so complete that the most delicate magneto will give no

ring when connected with the shell of the furnace and one of the iron terminals.

This other blue print shows another form of intermediary where a metal chimney or tube is lined with carbons through which broken carbons are supplied, and which descend and are



Showing self renewing electrodes of broken carbons and charging bell.



Smaller electric furnace showing electrodes and connections.

replaced from above as they wear away. They take current from the carbon lining of the conductor and carry it to the center and towards the bottom of the furnace.

They may be further reinforced by other broken carbons, being fed in through S, at a point farther into the furnace.

It is designed to so feed them that the weakest part of the circuit will always be near the bottom of the furnace. The conduits are passed through the shell of the furnace higher up on the shell but in a similar way to the other form of electrode. This arrangement makes a continuous self-renewing electrode, the weakest point in the circuit being where the two streams of broken carbons meet near the bottom of the furnace, the broken carbons taking all the wear.

Another form of intermediary electrode is shown in this blue print, which partakes of features of both forms of electrodes just described. In this, the carbon electrodes in the form of steps, are shown near the bottom of the furnace, and the intermediary is carried up in the form of a box to the top of the furnace, from whence it is connected with a cylindrical pipe which passes through a stuffing box through the top of the furnace to the exterior where it is connected with the aluminum bars to the dynamo. Through this cylinder broken carbons are fed down upon the carbons at the foot where they fall out and over the main carbon electrodes, reinforcing them and making them self-renewing and continuous. This form of electrode and furnace was devised that a comparatively small and really workable furnace might be obtained that would be thoroughly efficient.

The shell of the furnace is lined with asbestos, as are the others, inside of which is a lining of brick of smaller diameter, and leaving a space between its outside and the shell of the furnace. Into this periphery space is fed crushed sulphur, which is melted by the radial heat from the interior of the furnace, settles down and makes its way into and at the bottom through similar openings.

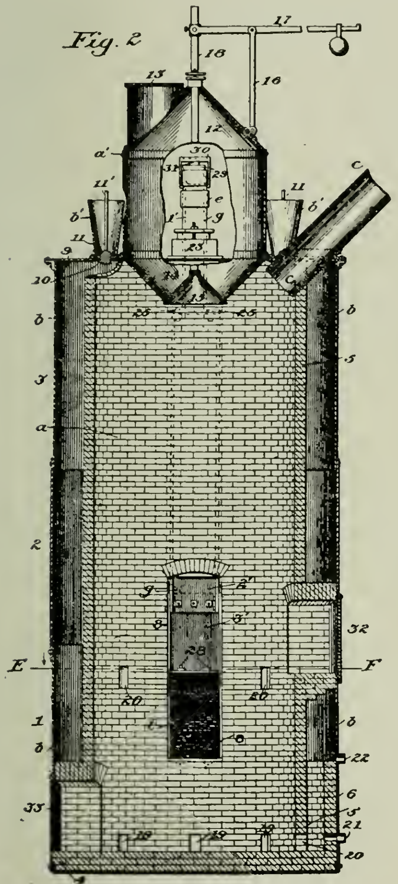
The charcoal is fed in through a hopper and bell as described in connection with other forms of construction.

This furnace is designed to be eight or ten feet in diameter and eighteen or twenty feet high, and will produce five thousand pounds per twenty-four hours with economy and satisfaction, while it could be pushed to a production of 10,000 pounds per twenty-four hours without trouble, with good advantage.

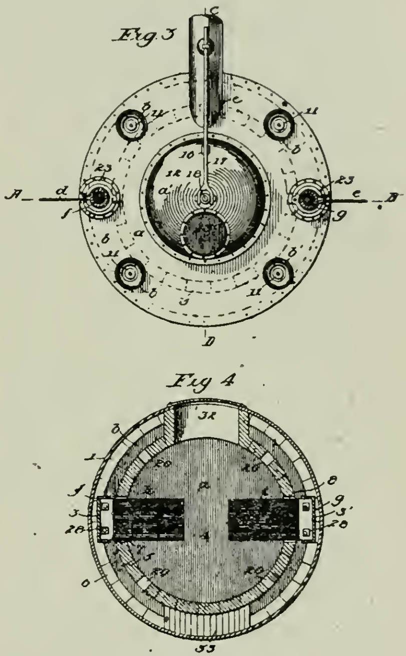
Two electrodes only are provided in this furnace, as a larger number would take up room more valuable for the materials of the reactions.

The broken carbons of course perform the same office as in the other construction.

The sockets which hold the main carbons are separate castings from that intermediary that connects with the outside of the fur-



Showing charging bell and sulphur space around the periphony.



Top view showing electrodes and connection periphony sulphur space.

nace, so if spoiled they can be detached and others supplied without the sacrifice of a large casting. Our experience is that these sockets can be used several times before they become so much injured as to require renewal.

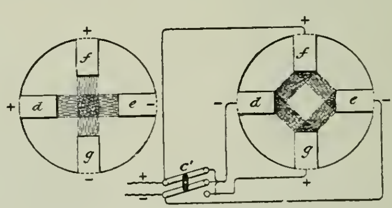
While this form was devised more especially for a compara-

tively small construction, there are principles in it that are very desirable in a large construction, and that will doubtless be so used.

With most electric furnaces the carbons figure up to a very heavy expense, but not so with these furnaces. The broken carbons are cheaper than the main carbons and are by this arrangement forced to the front, by means of which they take the wear and save the more expensive material.

To equip one of the large four-electrode furnaces with carbons costs one hundred and seventy-five dollars each time, but they last for a year or more without renewal, and make more than two million pounds of goods.

It will be seen that this combination of main and movable carbons in the interior of the furnace itself does away with the necessity of moving an electrode through the shell of the furnace from time to time and the insulation becomes permanent.



The four-electrode electrical furnace with two phase current to my mind presents many advantages. We usually pass the current through and through direct from one electrode to the other, but at any time when desired it can be changed to the adjacent electrode and then melt down or burn out any corners or pillars that may form and not be disposed to come down, thus any obstruction to the regular descent of the material may be removed. They also more completely centralize the heat in the hot zone of the furnace.

The electrodes are directly connected to the dynamo circuit without the intervention of transformers and the current regulated by the field and exciter reheostates with entire ease and satisfaction.

I doubt if the interior of the bi-sulphide of carbon furnace attains a temperature to exceed 1,000°, or at most 1,500° Fahren-

heit, and I would be prepared to see measured any temperature between these points as the practically constant temperature of the interior.

May I make my meaning clear without pretending to be literal, by saying the boiling point of the reaction.

For electric furnace work this is a comparatively low temperature. With other materials for a given reaction either a lower or a higher temperature may be the constant temperature.

There is a question as to the possibility of running a furnace of this type that will constantly maintain a very high temperature in the interior if the reacting materials will not be driven out or cannot be removed in a state of fusion, until such high temperature is attained; and we have proof of this in the first furnace four feet in diameter before referred to when the outer steel shell was so near the melting point that one of my men before I knew what he intended to do took a steel punch about sixteen inches long and pushed it through the shell as easy as though it were butter. Instantly I said, "Leave that there." What a nice time we would have had if he had pulled it out.*

There is no question about the ready application of these principles to other manufactures, especially when one of the constituent materials employed has a low melting point and good fluidity, like sulphur; and we may expect in the near future such developments.

For solid materials of difficult fusibility many difficulties present themselves in a furnace of this sort, but I am not without hope that such materials will ultimately be successfully worked; but it will have to be on a very large scale if at all, for solid bodies must have room in which to move to fulfill the conditions required,—quite likely mechanical action may be required to supplement the force of gravity.

As illustrating such a possibility, please notice the suggestion of such an endeavor illustrated by the blue print.

Between the interior hot reaction zone and the shell of the furnace which by the absorption of heat as it progresses shall keep the outer shell of the furnace at practically the temperature of the

*This high temperature was caused by our failure to feed in sulphur, thus giving the heat nothing to do but to accumulate in the interior till it had become so intense as to heat the shell as indicated.

surrounding air; with sufficient power in these present furnaces I believe this ideal condition could be reached. With this attained it is clear that the same ideal conditions can be reached with materials having much higher melting point than sulphur, and the use of this form of furnace not only greatly extended to other manufactures, but the practical size of furnace very greatly increased.

In this connection it is very interesting to note the progressive enlargement of the blast furnace, and to remark that nine blast furnaces erected during the first six months of the present year have a combined capacity equal to the entire production of pig iron in the United States in the year 1886, and which in that year required four hundred furnaces to produce. Yet of these nine furnaces built this year two of them were of such a size that seven such furnaces would be capable of producing more than the entire production of 1886, with its four hundred furnaces, and the probable maximum of large blast furnaces in all probability has not yet been attained.

Probably the blast furnace is the most economical furnace constructed, but the heating of useless nitrogen and the loss of heat from its sides is of necessity very great. It offers no such opportunity to cut off radiant heat as does the electric furnace, and while the advantages of increasing the size of blast furnaces has been very pronounced, the advantages of enlargement in electric furnaces are many times greater. Yet it must be admitted that most electric furnaces so far constructed have been very uneconomical, and especially wasteful of radiant heat,—yet in spite of these limitations the electric furnace is continually working into new fields, and will without doubt ultimately reach a perfection quite beyond the most efficient blast furnace.

Heretofore the gases from the electric furnace has been generally neglected.

It is very easy to see that an electric furnace constructed on the principles I have described is capable of utilizing all of the gases produced, and as no nitrogen is introduced the gases will be much richer and more valuable either for use in the gas engine or as a source of heat.

In the discussion on my first paper before the American Electrochemical Society, President Richards was kind enough to say:

"I think it is well to know that this furnace of Mr. Taylor's "has practically revolutionized the manufacture of carbon bi-sul-"phide in this country, and the size of the furnace is a revelation "of what may be expected in the size of electric furnaces in the "future."

May I also quote from my second paper before the same society at the first Niagara Falls meeting, *i. e.*: "In this connection "I will say that with this construction of the furnace and an ade-"quate source of electricity at my command, it would take less "nerve on my part with my present experience, to construct an "electric furnace that would dwarf the largest blast-furnaces "in existence to-day, than it took to build the furnaces now in use, "which are sixteen feet in diameter and forty-one feet high."

May I close this paper by quoting from a paper that I had the honor to read before the International Congress of Applied Chemistry at Berlin, in 1903, as follows:

"Having made provision for the movement and renewal of the "electrodes in the interior of the furnace itself, the introduction of "the conductor through the side or shell of the furnace (from "which it is insulated) is not only comparatively simple, but is of "a permanent character, and is shown at E in Fig 6. In this "construction, provision is also made at S for either the reinforce-"ment of these movable fragmentary electrodes, or for retarding "their conductivity by the introduction of non-conductive mate-"rial, or for the introduction of other material to be acted upon "in the furnace. A tap hole is also provided for the removal of "fused material.

"With these arrangements all the materials very gradually ap-"proach the heat zone of the furnace, and having entered into "combination under the best possible circumstances, the fused "product or residue makes its passage downwards, and the gase-"ous upwards, giving out heat as they go to the descending ma-"terial, and finally making their escape to the condenser through "the pipe shown at the top of the furnace.

"We have in this furnace the possibility of uniformly obtaining "the most suitable temperature (very high, very low, or any-"where between) for any given furnace reaction and maintaining "the same without fluctuation for days, weeks, or even months to-

"gether, a feature that will be greatly appreciated by working "chemists.

"All materials after having been once placed in the furnace "feed uniformly by gravity and fusion, giving such unity to the "whole as to give the best possible results from an economical point "of view, and creating in the mind of the worker a feeling of "great satisfaction, from the fact that troubles do not come to "disturb him and he can readily see a good reason for every-"thing he does. This encourages and stimulates his best endeav-"or and he becomes an enthusiast rather than a drudge, and his "labor a delight and pleasure.

"In most electric furnaces, more heat is wasted than is used. "In the one herein described, the loss is reduced to a minimum. "The whole operation takes place in a closed case protected from "any excess of heat, and lasts for many years without any import-"ant deterioration. The lining inside, after runs of many "months, requires only trivial repairs that are easily made. "When, therefore, to all of these considerations and others not "enumerated, it can be added that there is practically no limit to "the practicable size for such a furnace, except a market for the "goods and an adequate supply of crude materials and electricity, "its great advantages are obvious. We no longer need make bi-"sulphide of carbon in thimbles of furnaces; but any manufacture "it with ease in large quantities with an economy that ought to "largely extend its uses.

"As an illustration of the great advantage of a large furnace, "an earlier construction, ten feet in diameter and twenty-three "feet high, could be run continuously but a month or five weeks "at most, whereas, these sixteen by forty-one furnaces can be run "for many months in succession, and a furnace that would dwarf "the largest blast furnace in existence would probably offer cor-"responding advantages, both in economy and ease of manipu-"lation.

"We have made in this furnace fifteen thousand pounds in a "single twenty-four hours, and with more electricity in the same "furnace twenty-five thousand pounds can readily be made in that "time.

"It may also be said that the larger the furnace the easier it "can be worked, and it would seem that an operation that can be

"performed in a crucible, might be worked in this construction on "a scale almost bewildering to contemplate."

Coming now to our present gathering at the Franklin Institute, I may say, the market for bi-sulphide of carbon is a limited one and we cannot sell all we can make, and no larger furnace than those now in use would be justified under present conditions. But were the market for bi-sulphide of carbon as large and regular as the market for pig iron I would say the size of the future furnace need only be limited by the market for the goods and the amount of electricity available to put into it.

Book Notices.

NEW PUBLICATIONS.

The Universal System of Machine Moulding. Ph. Bonvillain & E. Ronceray. Catalogue. 96 pages, illustrations, 8-vo. Paris, n. d.

Pratt & Whitney Company. Small Tools, Standards and Gauges. Catalogue No. 4. 215 pages, illustrations, 12-mo. Hartford, Conn., Pratt & Whitney Co., 1907.

Pennsylvania State College Agricultural Experiment Station. Bulletin No. 71, revised edition. Relative value of feeding stuffs. Experiments with the respiration calorimeter in cöoperation with the Bureau of Animal Industry of the United States Department of Agriculture. 16 pages, 8-vo. State College, Penn'a, May, 1907.

Program and Papers. Brass Association Convention held with American Foundrymen's Association, May 20 to 24, 1907, Philadelphia. 26 pages, illustrations, 8-vo. New York, The Metal Industry, n. d.

Pennsylvania State Department of Agriculture. The Monthly Bulletin of the Division of Zoology, vol. 4, Nos. 11 and 12, March 1 and April 1, 1907. Plates, 8-vo. Harrisburg, Economic Entomologist of the Department, 1907.

U. S. Commissioner of Education. Report for the year ending June 30, 1905, two volumes, 1400 pages, 8-vo. Washington, Government Printing Office, 1907.

Forged and Rolled Steel Pipe Flanges special forgings, and full-size cross sections of flanges used in the different standards manufactured by the American Spiral Pipe Works. 93 pages, illustrations, 4-to. Chicago, 1907.

In opposition to the resolution reported from the Committee on Privileges and Elections. "That Reed Smoot is not entitled to a seat as a Sena-

tor of the United States from the State of Utah." Speech of Hon. Philander C. Knox, of Pennsylvania, in the Senate of the United States, Thursday, February 14, 1907. 19 pages, 8-vo. Washington, 1907.

U. S. Department of Agriculture. Farmers' Bulletin No. 277. The Use of Alcohol and Gasoline in Farm Engines, by Charles Edward Lucke and S. M. Woodward. 40 pages, illustrations. Washington, Government Printing Office, 1907.

University of Illinois Bulletin, vol. 4, No. 3, October 1, 1906. Chemical and biological survey of the waters of Illinois. Report for the year ending August 31, 1906, by Edward Bartow. Water Survey Series, No. 3. 30 pages, illustrations, plates, 8-vo. Urbana, University, n. d.

Investigation of the Thermal Conductivity of Concrete and the Effect of Heat upon Its Strength and Elastic Properties, by Ira H. Woolson.

Authorized reprint from the copyrighted proceedings of the American Society for Testing Materials, vol. 6, 1906. 25 pages, illustrations, 8-vo. Philadelphia, 1906.

Water Powers of Peru, their Development and Possible Applications. Utilization of the colossal hydraulic power of Lake Titicaca.

Abstract from the "Engineering Magazine." 8 pages, 8-vo.

Sections.

Mechanical and Engineering Section.—Stated meeting held Thursday evening, December 19, at 8 P.M. Mr. Charles Day in the chair. Present, forty-eight members and visitors.

The chairman introduced Mr. Axel Welin, A. I. N. A., London, England, who described and illustrated with the aid of lantern pictures, a series of inventions in connection with the operation of life boats on shipboard. The subject was freely discussed and the speaker's communication was referred for publication. Adjourned

Wm. H. Wahl, *Sec'y pro tem.*

The Franklin Institute.

(Proceedings of the annual meeting held Wednesday, January 15, 1908.)

Hall of the Institute,
Philadelphia, January 15, 1908.

President Walton Clark in the chair.

Present, 204 members and visitors.

The President presented the following report of the Board of Managers covering the operations of the Institute for the year 1907:

Members of the Franklin Institute:

The Board of Managers has briefly to report that the work of the Insti-

tute was conducted during the year 1907 very much in the usual successful manner.

A year ago the Board reported progress in the work of the Franklin Fund and Building Committee, in its efforts to secure for the Institute a new home in a more desirable location, and with improved facilities. The Board is pleasel to be able to now report further that it has subscriptions for an amount sufficient for the erection of a new building, better suited to the work of the Institute than is the old house, and much more advantageously located. It has not, however, subscriptions to a sufficient amount to insure the erection of a building which would be not only suitable to the work of the Institute, but would be architecturally an appropriate memorial to Benjamin Franklin. The work of securing contributions is therefore being continued.

The Board is unable, just at present, to make the usual annual financial statement, because of unavoidable delay in securing an audit of the Institute's affairs. The Board will report to you at the earliest possible date, on the financial condition of the Institute.

The various Committees of the Institute have performed their duties in the usual satisfactory manner.

The Committee on Science and the Arts has awarded six Elliott Cresson Medals, has recommended the awa d of five John Scott Legacy Premiums and Medals, and two Edv ard Longstreth Medals of Merit, for meritorious inventions.

The Library Committee reports the addition to the Library of 1005 bound volumes and 324 unbound volumes, representing a valuable addition to the Institute Library.

The Sections have exhibited the customary activity during the past year, and the *Journal* thereby has been enriched by the publication of many important technical communications. We record with special gratification the award during the past year of the Boyden Premium to a deserving and talented Philadelphia scientist, Dr. Paul R. Heyl, for his most ingenious determination of the velocity of transmission of the rays of the ultra-violet portion of the spectrum.

The School Work of the Institute has been continued with success. The number of pupils in the Spring Term of the several schools was 163, and in the Winter Term 194, making a total of 357.

The Committee on Election and Resignation of Members reports the election of sixty-nine members during the year 1907.

In conclusion, the Board congratulates you that another year of useful life has been added to the honorable record of our venerable institution. The value of the work of Franklin Institute is appreciated highly and properly by our fellow citizens, as well as by the scientific men of the world. This has been again made apparent by the interest shown in our project for securing improved opportunities and appliances for useful work; and should encourage us to a new resolution that our Institute shall continue to be increasingly worthy to bear the name of Benjamin Franklin.

Personally, I thank you that you have thought safe to continue me in a position of responsibility in the honorable work of the Institute.

WALTON CLARK, *President.*

PHILADELPHIA, Jan. 15, 1908.

The report was accepted.

The paper of the evening was read by Mr. Patrick B. Delany, of East Orange, N. J., on the "Telepost." The speaker described an interesting development of his system of rapid automatic telegraphy, by which it could be applied advantageously to the postal service.

The system was exhibited in operation by a completely installed outfit of the apparatus employed, and the details were described with the aid of lantern photographs.

The subject was freely discussed.

At the close of the discussion the invention was referred to the Committee on Science and the Arts for investigation and report. The speaker received a vote of thanks for his interesting communication, which was referred to the Committee on Publications.

The Tellers of the Annual Election presented their report, which was accepted and the thanks of the meeting were tendered to them for their services. The result of the election was as follows:

For President,	(to serve one year).............	WALTON CLARK.
" *Vice-President,*	(" three years)...........	WASHINGTON JONES.
" *Treasurer,*	(" one year).............	CYRUS BORGNER.
" *Secretary,*	(" one year).............	WILLIAM H. WAHL.
" *Auditor,*	(" three years)...........	WILLIAM H. GREENE.

For Managers (to serve three years).

JOHN BIRKINBINE,
JAMES CHRISTIE,
THOMAS P. CONARD,
WALTON FORSTALL,
LOUIS E. LEVY,
RICHARD WALN MEIRS,
ISAAC NORRIS, JR.,
COLEMAN SELLERS, JR.

(To serve two years.)
CHAS. E. RONALDSON.

For the Committee on the Science and the Arts (to serve three years).

A. W. ALLEN,
CARL G. BARTH,
HUGO BILGRAM,
FRANK P. BROWN,
KERN DODGE,
W. C. L. EGLIN,
J. LOGAN FITTS,
EDWARD GOLDSMITH,
CASPAR WISTAR HAINES,
CLARENCE A. HALL,
LEWIS M. HAUPT,
ROBERT JOB,
G. H. MEEKER,
LUCIEN E. PICOLET,
JAMES S. ROGERS,
E. ALEX. SCOTT,
HARRISON SOUDER,
MARTIN I. WILBERT,
RICHARD ZECKWER,
CHAS. J. ZENTMAYER.

(To serve two years.)
EUGENE S. POWERS.

Adjourned.

WM. H. WAHL, *Secretary.*

Yours faithfully
Coleman Sellers

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA

FOR THE PROMOTION OF THE MECHANIC ARTS

VOL. CLXV, No. 3 | 83RD YEAR | MARCH, 1908

THE FRANKLIN INSTITUTE.

In Memoriam.

COLEMAN SELLERS.

January 28, 1827—December 28, 1907.

*The loss of this valuable citizen and great director of industry will be felt throughout the world of enterprise and education, but nowhere more acutely than by the Franklin Institute, of which he was for five years the President, and for twenty-three years Professor of Mechanics.

A grandson of Nathan Sellers, surveyor, conveyancer, and Ensign in a company of Pennsylvania Associators which took the field with General Washington in the Long Island campaign of 1776, a skilled mechanic of such ability as to induce Congress

*Many of the data in this short memorial sketch have been based on the article of the late Dr. Henry Morton in Cassier's Magazine for August, 1903.

on the petition of the American paper manufacturers, to re-call him from military service to inaugurate the manufacture of paper for cartridges; son of Coleman Sellers, inventor and mechanic: grandson on his maternal side of Charles Wilson Peale, the gifted artist, soldier, naturalist, and statesman: Dr. Coleman Sellers had through heredity the genius of observation, comprehension, and achievement.

He was born in Philadelphia January 28, 1827, but had the misfortune to lose his father by death when he was but seven years old. After a rudimentary education in private schools, supplemented by the instruction of his mother in a system of manual training of her own devising, he entered the academy of Anthony Bolmar, of West Chester, Penna., in 1838, at the age of eleven. At the very outset his imagination was stimulated by the simple experiments in natural philosophy which his instructors employed, and at once he began a career of invention, which never actually terminated till his death. Six years were passed at the West Chester school, which he left in 1844 at the age of seventeen.

The career selected for Dr. Sellers by his mother was that of a farmer, and two years were spent on a farm. But this occupation did not fulfil his yearning to use the faculties which he felt within him, though it served to draw from his practical mind an early invention which, like many of his subsequent inventions, anticipated the essential features of a construction destined to universal use, viz., the metal-pronged hay-rake on wheels. At nineteen he entered the service of his older brothers, Charles and George Escol Sellers, in the Globe rolling mill at Cincinnati, Ohio. Here he remained three years, part of the time as Superintendent of the works; after which he became foreman of Niles & Company, locomotive builders.

His familiarity with all forms of rolled and drawn metal at this time, and especially his practice in producing iron wire for a telegraph constructor, induced him to take up and repeat some of the experiments of Michael Faraday. He also devoted part of his leisure to the making of collections in natural history, and to the study of Swedenborg's philosophy. In 1851, he married Miss Cornelia Wells, of Cincinnati, and in 1856 returned to Philadelphia and became chief engineer of the machine tool works of his cousins, William Sellers & Co. This position he retained for thirty

years, during which time he made many improvements in the tools and processes of this leading American establishment.

Every change of occupation was marked by his development of a new and correlated study. Just as farming stimulated him to invent the metal rake, and drawing iron wire led him to the study of some of the phenomena of electricity which the wire was intended to convey, so his management of the draughting room of William Sellers & Co. suggested to him, in 1858, the use of photography as an aid to the methods then in use for illustrations of machinery. He took the art up and very soon perfected himself in applying it. This again led him to devise a rough prototype of the Kinemetographs, now in use for exhibiting moving pictures.

Similarly having occasion to use the microscope, which had not previously engaged his attention, he rapidly attained the skill necessary to prepare and mount thin sections of solid objects, a process which had been applied to the study of mineralogy by Vogelsang, and later Zirkel, about 1868 to 1870.

But he did not stop here. Being now completely established in his triple character of practical manufacturer, scientific experimenter, and teacher, he arranged a projecting lantern to show these slides on the screen by the aid of the oxy-hydrogen light; and to obtain this light he manufactured the oxygen, as this gas was not then a purchasable commodity.

Those who attended the lectures on Mechanics which Dr. Sellers gave during several seasons at the Franklin Institute, will recall his happy faculty of explaining a difficult problem or an intricate piece of mechanism in simple words so that his hearers could not fail to understand the subject. A number of these lectures were stenographically reported, and are preserved in the pages of the *Journal* of the Institute. Dr. Sellers' contributions to the *Journal* cover a wide range of topics, which if collected together, would make a good-sized volume. His latest articles refer to the preliminary meetings held in New York and London to consider the practicability of generating electrical power at Niagara Falls, the conferences of the International Niagara Commission, and also describe some of the final plans adopted. Dr. Sellers was chairman of the Board of Engineers appointed to carry out the plans, many of which were of his own devising. When the tunnel was nearly completed and the time for the instal-

lation of the machinery was near at hand, the object of the Board of Engineers had been accomplished, and it was dissolved. Dr. Morton said, in the article already mentioned: "It then became preëminently the task of the mechanical engineer to consider and apply the devices best adapted to so control and utilize the forces as to secure the best engineering and commercial results. Dr. Sellers was accordingly made chief engineer of the Cataract Construction Company, and while its separate organization was called for he served also as president of the Niagara Falls Power Company. It thus devolved upon him to suggest and devise the various details of the installation at a time when its principal features were essentially experimental, and it is needless to say how successful has been the outcome of the conservative course pursued by him throughout his active connection with this work." It is hard to realize in these days of electrical development, that when the Niagara Falls project was conceived little was known definitely about many questions which have since been clearly determined, and are now almost matters of common knowledge. Prior to 1893 the largest generators in the world were not over 2000 H.P. in output, and though in Switzerland some generators had been made operated by vertical shafts directly from water-wheels, there were none approximating in size the units selected for Niagara, nor were any driven by vertical shafts of the length and speed required in the new installation. Perhaps the most important work done for the Niagara Falls Power Company by Dr. Sellers was in shaping the policy of the Company in regard to certain of these important questions which arose, especially during the sittings of the International Commission in London, and during the constructive period, from 1889 to 1893. On many of these questions there was the greatest diversity of opinion and conviction among the technical advisers of the Company; and wise judgment, great tact, and courage were required to select and determine the best course to pursue, and to harmonize the various conflicting views. One of the first of these grave questions arose in London, when Sir William Thompson (Lord Kelvin) offered a resolution committing the Company definitively to the use of the direct current. This Dr. Sellers opposed successfully on the ground that the possibilities of the alternating current at that time were not sufficiently understood to justify such action. When, at a somewhat later period, the alternating

current had been finally decided on, the number of phases and voltage had to be settled and the relative advantages considered in the light of the limited knowledge of that time. It required almost a prophetic insight to forecast the probable course of electric development, and though not a professional electrician, Dr. Sellers was able to grasp the most technical questions by means of the thorough knowledge of principles which he acquired as a young man through experimental work done during his limited leisure time.

While acting as Chief Engineer of the machine tool works of William Sellers & Co., Dr. Sellers invented many new and ingenious devices that contributed largely to the success of that firm and gave to it the international reputation which it still retains. Among the best known early inventions is the double-cone coupling for shafts, which was probably the first successful substitute for the flange, or plate coupling, previously used. This invention made a radical change in the manufacture of shafting, cheapening the cost of production, and greatly facilitating installation and repair.

Among the twenty or more patents which were taken out by Dr. Sellers in the interest of William Sellers & Co., either alone or with others, while he was connected with the house, we find a variety of subjects which gives indication of the versatility of his mind. Besides the shaft-coupling already mentioned, we note improvements in Injectors for feeding boilers; a machine for rifling gun barrels; an automatic stop for bolt cutters; coupled with an improved oiling device by which the lubricant was delivered through the center of the die box directly on the work; improvements in punching and shearing machines; an original type of turn-table for pivot bridges; automatic valve gear for steam hammers; numerous improvements in hydraulic presses, of which probably the most notable was an ingenious method of lining cylinders with copper, so as to prevent the passage of the fluid into the casting of which the cylinder is composed; automatic relief valve for hydraulic accumulators; a slide valve for the steam riveter, permitting the steam used in making a stroke to act expansively and withdraw the ram for the next stroke; improvements in presses for putting railway wheels on their axles, which is substantially the type of machine now universally used; an ingenious friction device for machine tool feed motions, by which

an infinite number of gradations in amount of feed can be obtained by the simple movement of a lever. Another feed motion patent covers an ingenious application of the epicylic train or "sun and planet motion," for transmitting either a slow feed movement or a rapid traverse for adjustment through the same mechanism. He also invented an interesting device for transmitting motion but preventing reaction.

All of the machine tools designed by Dr. Sellers were characterized by simplicity of design and beauty of form; they possess a distinct individuality that enables an expert to recognize them at a glance without referring to the name-plate on the machine.

As an illustration of Dr. Seller's keenness of perception and fertility of resources, an incident may be briefly mentioned here, chiefly because it has never been elsewhere recorded. About the year 1868, an inventor brought to the Franklin Institute for examination a lock which he confidently declared to be "unpickable." There was no key-hole visible, but on very close inspection it was apparent that a small square hole had been cut out of the steel plate forming the outside cover of the lock and a small plate of steel had been accurately fitted therein and polished to match the rest of the surface. Various unsuccessful attempts had been made by the writer and others to draw out this small square morticed plate, when Dr. Sellers happened to come into the office, and after examining the lock for a minute, he procured a small piece of beeswax and a little piece of thin spring steel; bending this into the form of a bow he attached the beeswax in the middle of the spring and pressed it firmly against the inserted square plate; on removing his thumb the steel bow sprang up bringing the square plate with it and revealing a key hole beneath. Dr. Sellers then made a false key with two pieces of wire and in a few minutes he successfully picked the lock, greatly to the discomfiture of the inventor and surprise of the other spectators. The inventor stated that he used a horse-shoe magnet to withdraw the square plate covering the key hole, and had never thought of Dr. Sellers' simple scheme.

Dr. Sellers was elected to membership in the Franklin Institute in 1858, two years after his return to Philadelphia, and from the first, took an active and prominent part in its affairs. He was elected to the Board of Managers of the Institute in 1862, and served continuously on the Board from that time until re-

cently, when physical infirmity caused him to withdraw. He became President of the Institute in 1870, and served in that office until 1874. He was also for many years a member of the Committee on Publications; and of the Committee on Science and the Arts. In 1899, as a recognition of his long and valued services in furthering the work of the Institute, he was made an Honorary Member on the occasion of the celebration of the 75th anniversary of its foundation, when he delivered an address on "The Progress of the Mechanical Arts in three-quarters of a Century."

His contributions to the *Journal* of the Institute during the long period of his active participation in its work were very numerous —no less than twenty-nine titles appearing to his credit in the several indexes, covering a wide range of subjects and constituting an interesting tribute to the versatility of the author's knowledge.

Possessed of much sympathy and social instinct, and a large fund of quiet humor, it was impossible that Dr. Sellers' aptitude for experimentation, and his ingenuity in the production of new phenomena should not have led him to the application of his talent for the amusement and instruction of others. So from his early years he was expert in the magician's art and in thaumaturgy. These talents were like all else of his, used for the highest purposes. They beguiled many a sufferer in a military hospital during the civil war, and later they were turned to the good account of the entire community when he served as a member of the Seybert Commission to investigate the phenomena of Spiritualism.

He could readily reproduce, under similar conditions, all the mysterious happenings which were shown him, and thus afforded the most valuable object lessons of the futility of basing conceptions of the Universe and life upon the interpretations a casual visitor might make of the sensations of sight, sound, touch, taste, and odor which he might experience.

In 1884 he visited Europe for the first time, representing this Institute as its Professor of Mechanics and delegate to the tercentennary of the foundation of the University of Edinburg. This professorship he filled honorably for twenty-three years, until his decease.

In 1886, he again went to Europe, and on his return was compelled by ill health to resign his position as Engineer of Wm. Sel-

lers & Co., Inc., and other permanent duties, but continued his activities as a consulting engineer. As soon as this became known, the Stevens Institute of Technology established a chair of Engineering Practice, and called Dr. Sellers to fill it as a non-resident member of the faculty. The chair was intended originally as a paene-graduate course for the Senior class, but his lectures were attended by the members of the Faculty also, who received from them, as Dr. Morton, the President of the Stevens Institute, says, many hints which aided them in their several courses of instruction. In 1887, Dr. Sellers received from the Stevens Institute the honorary degree of Doctor of Engineering, and in 1899, that of Doctor of Science from the University of Pennsylvania.

But the crowning glory of his professional career was his wise direction of the Niagara Falls Power Company. This has been before alluded to, and is familiar to all scientific men throughout the world.

Any one of the half dozen connections which Dr. Sellers had with this great enterprise would have sufficed to make the reputation of an engineer, and would be cherished as an honor by his descendants.

Beginning with the request of Mr. E. D. Adams, of New York, in 1889, that he report on the practicability of generating electricity for the transmission of power from Niagara Falls, through his chairmanship of the Cataract Construction Company; his participation in 1890 in the organization of the International Niagara Commission at London (thus meeting as colleagues Lord Kelvin, Lt. Col. Turrettini, Prof. Mascart, and Prof. W. C. Unwin); his appointment as Chief Engineer of the Construction Company; and terminating with his great success in planting the enterprise on a stable and profitable foundation; this part of his life is unsurpassable for successful achievement.

As a man, his history is not less notable. Gentle, unassuming, kind, and considerate, his social nature, even to those not of his intimate acquaintance, was most attractive. As a citizen he was not afraid to denounce wrong and to uphold right, even in the face of popular clamor.

Whatever views Dr. Sellers held on any subject one was sure, not only that they were the result of careful thought, but that they were the honest outcome of that thought. Of him we can say:

"Semper honos nomenque tuum laudesque manebunt."

(Annual Meeting, held Wednesday, January 15th, 1908)

"Electro-Magnetic" Automatic Telegraphy.
(The "Telepost.")

By Patrick B. Delany.

A little more than eleven years ago it was my privilege to bring before the Institute certain improvements in Automatic or machine telegraphy. It is my purpose this evening to show and explain a new method which is the logical outcome of results obtained with that system, and due to experimentation carried on continuously since that time.

Before taking up the main subject, however, I wish to bring to your attention certain developments in what might be called "Electro-Magnetic" Automatic Telegraphy, to distinguish it from the much more rapid "Electro-Chemical" system, in which no electro-magnets are used.

As you all know about the ordinary Morse system, comprising the relay, sounder and key, it will be easy to understand the modifications by which it is proposed to improve Morse working, to the extent of quadrupling its present message capacity, whether the wire be used for simplex, duplex or quadruplex transmission.

In these days it is hardly worth while, however, to include the Morse Quadruplex in any practical estimate, as its day is about done, owing to increasing underground construction and inductive interferences from power wires. Wherever operable, however, the ratio of gain will hold.

The President of the Western Union Telegraph Company stated publicly last April that 99 per cent. of the messages handled in this country were still transmitted by the old-fashioned Morse key, at a speed averaging seventeen messages an hour, and stated also that this was considerably less than the speed of several years ago. Allowing thirty words for each message, including ad-

dress, date and signature this shows an average of nine words per minute per circuit. Thus it seems that while the transfer of energy over a wire in another department of electricity has been increased from a few hundred volts to seventy-five thousand within the last twenty years, the transfer of *words* has fallen off during the same period, and is now about one-fortieth of what a wire is able to convey.

Up to a few years ago there was strong opposition on the part of telegraph companies to the preparation of messages on tapes

Fig. 3. Keyboard.

preliminary to their transmission, but it is now conceded that in no other way can the speed of a circuit be appreciably increased, and the perforated tape is coming into use for even unimportant advances in telegraphy.

In the Electro-Magnetic Automatic System which I am about to show you the message is composed on a tape precisely as for the Electro-Chemical Automatic, which will be shown later. The Perforator (Fig. 1), (cut omitted), may be operated by the ordinary Morse key, the Auto-Dot Key (Fig. 2), (cut omitted), or by the Keyboard Transmitter (Fig. 3.) These transmitters may be

located in branch offices of a city, or at way stations, so that messages may be perforated from any distance at a central office ready for transmission at a high rate of speed over the trunk lines.

Fig. 4 is a diagram of the perforator connections. When the Morse key K is pressed down the circuit of battery B is completed through magnet M^1, contact C^1, rocking beam D, back to the battery, energizing magnet M, and attracting its lever L, which forces the punch P^1 through the tape Q. Just as the punch enters the tape the pin on the lever L pulls the tapering end of rocking beam D past its biasing spring X, on the end of which is a small roller, thereby breaking the circuit of Magnet M at C. This allows lever L to fly back to its stop V, after having made a hole in the lower edge of the tape. The rocking beam D, having

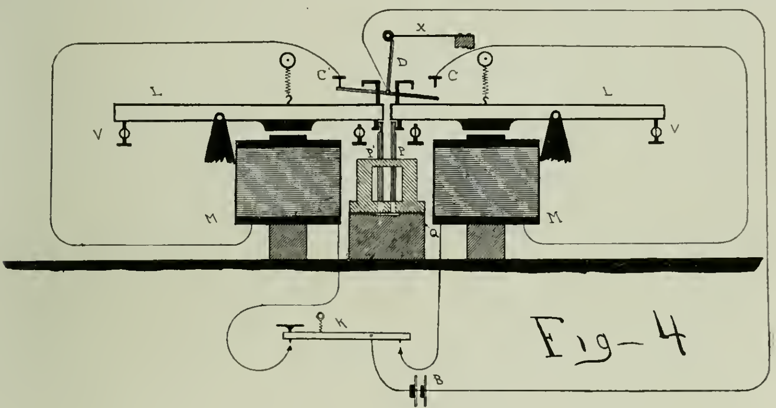


Fig. 4. Perforator and connections.

been moved to the left, the circuit of M is now closed at contact C, so that when the Morse key K reaches its back stop, magnet M is energized, lever L attracted, and punch P is forced through the tape, making a hole in the upper side. The tape is constantly running, but the action of the punchers is so quick, its movement is not perceptively checked. Thus, the perforating operator works his key in the regular way, the dots showing a slight angle on the tape, the dashes and angles corresponding to the time the key is held down.

Fig. 5 is a diagram of the Keyboard connections.

As the key K is pushed down and locked at L, spring S presses on sliding bar B, clamping it between revolving

rollers R and R[1]. Contact finger F is drawn over the row of contact segments, which in this case represents a period,—two dots, two dashes, two dots. As the finger F passes over the segments the circuit of the transmitter relay T is made and broken through battery A and the characters formed. The armature lever H of relay T is connected to the line W. Its front stop is connected to the main battery A. At the completion of the movement forward of bar B, the latch spring L is pushed back and the key K released. As K rises it pulls bar B up with it by loop V,

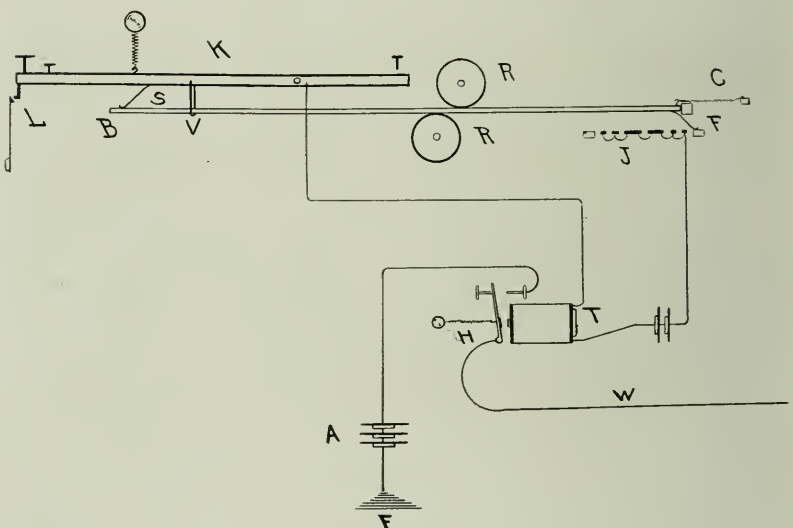


Fig. 5. Keyboard connections.

releasing it from the grip of rollers R R[1], when it is pulled back to the starting point by spring C. This backward movement is so quick the transmitter T is not actuated even with the lowest adjustment of the armature spring. In this way all mechanical or electrical contrivances for taking the contact maker F out of touch with the character segments on its return are unnecessary.

Four operators may be employed in perforating tapes by Morse key at the rate of twenty-five words per minute each, and the product of their united work sent through the Mechanical transmitter and reproduced on a perforated tape at the distant station. The tape is then distributed among four local circuits where a perfect reproduction of the original characters are ticked

off on the sounder and copied on the typewriting machine by the operator, just as if the characters were coming over the wire from the operator's key direct. Fig. 6 shows the transmitter in operation and Fig. 7 the reproducer at the receiving station (cut omitted). As a matter of fact, the original manipulation of an operator in preparing the message is greatly improved by the perforating process, since all impulses, whether regularly or imperfectly made by the operator's key, make the same sized hole in the tape. The impulses over the line must threfore be all uni-

No. 6. Transmitter in operation.

form. Of course, the variations in length of dashes or spaces will be faithfully duplicated on the receiving tape, but the evenness of impulses passing over the line from the uniform perforations greatly improves the general quality of the work. Obviously, the original preparation of the message and the transcription by sound may be carried on at any rate that the operator is capable of perforating or reading by sound. For instance, a Keyboard Morse transmitter can be used for perforating at fifty words per minute, there being no interruptions incidental to a line, and no

operator at the distant end to limit manipulation by the perforating operator. Similarly, the operator reading by sound from the reproduced tape at the receiving station may regulate the speed of his tape to any rate that he is capable of reading and working his typewriter, and may confirm any doubtful word by looking at the perforation. Of course, transcription may be done by reading from the tape direct by those not proficient in reading by sound.

An inexperienced operator at some way station may perforate ten words per minute, the message goes over the line at 100 words per minute, and is transcribed by sound, locally, at the receiving station at twenty-five words per minute. Ordinarily, if this message was sent directly over the line the entire use of the wire would be monopolized by the slow operator.

For through business, New York to San Francisco, for instance, a tape can be reproduced in Buffalo and used for transmission into a Chicago circuit, where another reproduction can be used for transmission to Denver, then again reproduced at Salt Lake, and finally at San Francisco, at 100 words per minute, as against an average of about twelve words by the present Morse method, using five or six automatic repeaters. Instead of perforating tapes, repetition may be effected by the movement of the perforating lever, or perforation and repeating may be done simultaneously at any station.

Duplexed, this system would yield 200 words per minute in perfect Morse, and without the slightest deviation from the regular Morse method, the sender working his key, and the receiver copying by sound, while the message capacity of the duplexed wire is increased from about forty words per minute to 200.

A most important application of this system will be for the distribution of press news. Drop copies can be made at 100 words per minute at thirty to forty way offices, either perforated on a tape for operation of a local sounder at any speed desired, or recorded in plain dots and dashes for deliverate transcription by those who cannot read by sound. A linotype operator knowing the Morse code will be able to compose directly from the tape. The reproduced perforated tapes may be used for re-transmission over other circuits, so that a news dispatch perforated in New York may be distributed all over the country, and news-

papers now too poor to buy press matter may be supplied at a nominal charge.

Coming now to the rapid automatic system which records one thousand words per minute, it may be said that the system originally brought before the Institute had as its main feature a method for recording signals in a special manner, with the view of overcoming the effects of static discharge.

A few words in an elementary way explanatory of this static discharge may be helpful to a better understanding of the means through which it is sought to surmount this most formidable obstacle in the way of rapid transmission.

The electro-static capacity of a line is its capacity to hold current, and this capacity has to be satisfied before a signal can be manifested at the distant station, and the charge left in the wire after the signal has been delivered must be discharged to ground or neutralized by a reverse current before another signal can arrive. The electro-static capacity of a wire is increased by its envelope, whether it be air, or insulating material. The static discharge after each impulse runs out at the ends of the wire, about two-thirds coming back to the sending station, and one-third following the signal impulse on to the receiving station. The portion coming back is an obstacle in the way of the next signal, and the portion running out has the effect of elongating the signal which it follows, and if the signals are too close together and the wire long enough, they will appear on the recording tape as a solid line without definition, so that letter p, comprising five dots, would look like letter l, which is a long dash. The remedies for this very troublesome obstacle in the past have been transmission of reverse impulses after each signal, so as to neutralize the static discharge in the line, or connecting the line to ground after each signal, so as to let the static run out. Another way was to put artificial leaks or partial grounds at different points along the line and work over them by surplus power.

The first of these remedies is the only one that is practically effective, as the static discharge can be neutralized in about one-tenth of the time taken for its discharge to ground.

Fig. 8.—A represents a record at a speed of 300 words per minute over a line ten miles long having very little, or inappreciable static capacity

B represents the same word at the same speed over a line 100 miles long, and having considerable capacity.

C represents this word over a line 500 miles long.

The improvement referred to for remedying this trouble consisted of an arrangement for differentiating the dots from the dashes, putting them in different lines, and making two marks for a dash to further distinguish it from an elongated dot or a series of them, so that the blurring or "tailing" effect might be disregarded to an extent which doubled the speed of transmission.

In drawing comparisons between this system and the latest method of rapid telegraphy, it may be said that this had the dis-

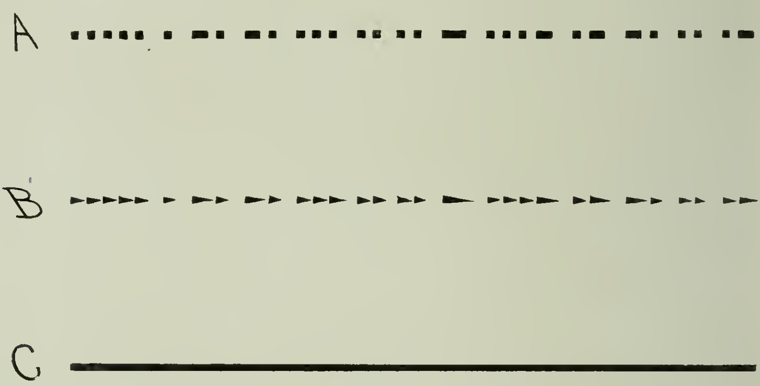


Fig. 8. 3 samples tape A B C.

advantage of requiring a three-keyed perforator, somewhat similar to that used in the Wheatstone System for preparation of tapes, and consequently, necessitated special training of operators, and also required the use of the continental code or modification of the American Morse Code.

Coming now to Rapid Automatic Telegraphy of to-day, adapted to all distances and conditions, it will be seen that in the formation of dots the static discharge is *neutralized* by reversals, and *utilized* for completion of dashes, which are really dot impulses, supplemented by the discharge, and when under certain conditions, the discharge from the line is not sufficient to draw out the dash to the required length, it is increased by adding "capacity" through the medium of a condenser between the line and ground.

Fig. 9 is a diagramatic representation of the Telepost circuit.

The sending tape T shows two rows of perforations. Each signal, dot or dash, is represented by two holes, one in the lower row, the other in the top row. Positive impulses are made through the lower row, negative impulses through the top row. All the positive impulses make a record on the receiving tape R.

The negative impulses from the upper row do not record, being represented by the spaces between successive dots.

The pairs of perforations representing dots are just out of perpendicular, so that in passing between the contact fingers of the transmitter they will not bridge.

The contact fingers F pressing on top of the tape are electrically one and are connected to the line, the contact fingers pressing up-

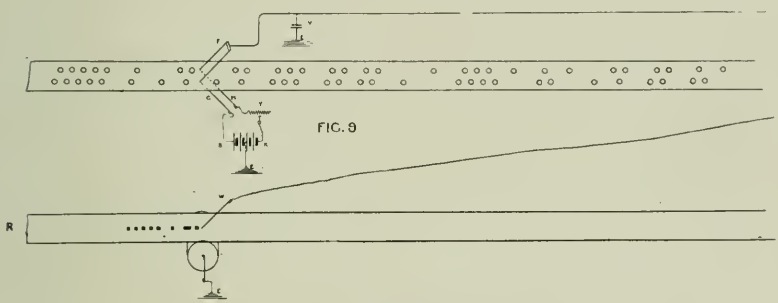


Fig. 9. Telepost circuit.

ward underneath the tape are separate, C, being connected to the positive current, B, while H is connected to the negative current, K. The battery is grounded in the middle at G. When the tape is drawn by the motor M (not shown), and the lower hole allows contact fingers, F and C, to come together a positive impulse is sent over the line and is recorded on the receiving tape R as a dot. When a hole in the upper row permits contact, F and H, to come together a negative impulse goes over the line, but it makes no mark on tape R. It performs useful work, however, in preventing the positive dots from running together on the receiving tape. In the case of a dash, the positive and negative holes in the tape have a greater angle. The negative does not follow the positive immediately, as in the dot. It is set back a distance representing a dash; therefore, while the contact fingers, F, C, are separated by the tape some of the static charge is running out at the

receiving station and continues the mark which started with the dash impulse until the contact F, H come together in the delayed upper hole and a negative impulse is sent to cut off the dash at a corresponding length. It will be understood that the record on tape R is made by electro-chemical action. The tape R is dampened with ferro-cyanide and certain other chemicals, which when acted upon by a positive electric current decomposes the iron recording wire W, leaving an indellible mark. Now, as already stated, where there is not sufficient discharge at the receiving end of the line the condenser V can be regulated to make up the deficiency. This condenser is charged at the same time as the wire, and its discharge follows up the signal impulses so as to prolong the "tailing" on the receiving tape. If a few miles of underground cable were included in the circuit, they would take the place of the condenser, going to show that underground lines, so difficult for electro-magnetic telegraphy, are conducive to the operation of this rapid system up to certain limits. Of course, it is possible to have an excess of static capacity, but when this point is reached there is a means whereby the best results possible under the circumstances can be reached. It lies in the regulation of the power of the negative impulses, and adapting them to the requirements for density and definition in the record. With a line having just enough capacity to fill out the dashes, the negative current should be considerably weaker than the positive. If of equal strength, the recorded impulses would be too short and faint. If on the contrary there is too much capacity the negative current may be strengthened. The regulation of the negative is effected through the adjustable resistance shown. (Y Fig. 9.)

It will be seen that in this system three very important factors are combined for obtaining the best results from a telegraph circuit, viz., first, a positive current sufficiently powerful to make the record electro-chemically in the shortest possible time. Second, a regulable source of Electro-static capacity for use where the normal capacity is not enough to make a dash. Third, adapting the power of the negative current to the electro-static capacity of the line, normal, or artificially augmented, to give the record the maximum plainness consistent with safe separation of the characters, so as to make transcription easy and accurate.

It is thought that in this organization is reached the highest signalling efficiency for all conditions of lines, overhead, under-

ground, long or short. There are no electro-magnets to energize, no armature to actuate, no inertia to overcome, or electro-mechanical work to do. The chemically prepared tape is a part of the circuit, and the characters are made simply by the current passing through it. Once installed on a line, there is practically no adjusting to do. A change in weather conditions sufficient to put out of operation any electro-magnetic system does not seriously interfere with the electro-chemical. Half the current might be suddenly diverted during transmission without loss of any of the characters. The record would be fainter, but no impulses would be missing.

The system can be superimposed on a telephone circuit and worked simultaneously with telephony at about two-thirds of its independent speed.

While our time has been taken up with the main electrical methods, it may be said that there are numerous features of operation and control which are indispensable for practical commercial telegraphy. The demonstration will show that as the tape bearing the message comes from the perforator it is automatically wound upon a reel, and whether there be one or a dozen messages, or 500 words to press, the tape is a single unit, and goes through the transmitter last end first.

At the receiving station, the tape is also wound upon a reel which brings it right end first,—for transcription. The received tape is drawn in plain view of the transcribing operator by means under his own control, not continuously moving, but in fixed steps, so that it is at rest while being read. The receiving machine is under control of the transmitting station. When the transmitting lever is put down to start the tape, an impulse is sent which starts the receiving tape. When the transmitting tape runs out another impulse is automatically sent which stops the receiving tape. Should the receiving operator wish to stop the transmitting machine he can do so, and the transmitting operator can stop the receiving machine at any stage. Should the wire come accidentally in contact with another both machines would be thrown out of operation.

Fig. 10 shows the message being composed on the tape by the ordinary Morse key.

Fig. 11 shows it going through the transmitter (cut omitted).

Fig. 12 shows reception of the message on the chemical tape.

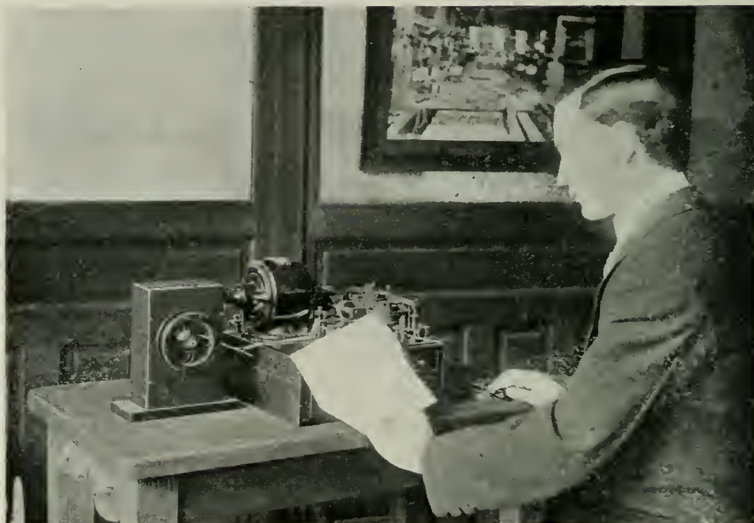


Fig 10. Perforating by Morse key.

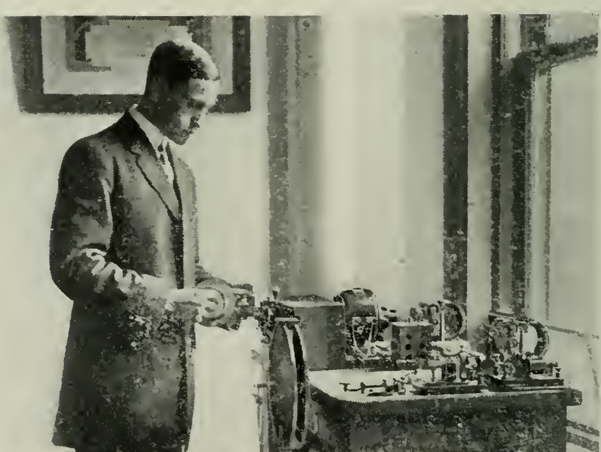


Fig. 12. Rapid Receiver in operation.

Fig. 13. Transcribing from rapid tape.

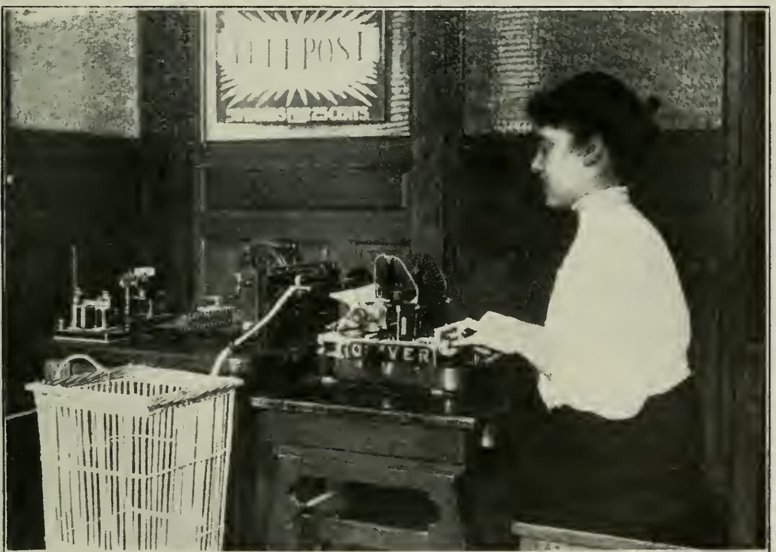


Fig. 14. Reading by sound from received perforated tape.

Fig. 13 shows the received message on the transcribing table.

Fig. 14 reading by sound from perforated tape.

Fig. 15 shows specimen of a recorded telepost message at 1,000 words per minute over a line representing 500 miles, 1,000 ohms, $2\frac{1}{2}$ microfarads, with 110 volts.

At this speed eighty-two persons would be kept busy over a single wire, forty perforated messages for transmission, forty transcribing them by typewriter, and two machine tenders. This would be more than the equivalent of forty Morse circuits as at present operated.

It is only by the utilization of the full facilities of a wire that a Telepost service can be established. Cheap rates are impossible at nine words per minute. At 500 to 1,000 words per minute low charges can be brought to apply to ordinary correspondence now sent by rail. When a letter of fifty words filed in the Telepost office in Philadelphia can be dropped in a post office in Chicago, or any other city, within half an hour for twenty-five cents, an

Fig. 15. "The Telepost" tape.

enormous traffic will be speedily developed. It will be entirely feasible for business houses or newspaper correspondents to compose their letters or reports on a tape in their own offices by keyboard machine, send the tape in a roll to the Telepost office, where it will be forwarded without delay, and have the record tape delivered to the party at the other end, for private transcription. In this way correspondence would be absolutely private, for if desired, the perforated tape could be returned to the sender. Here the telegraph toll would be merely nominal.

There is nothing now between the high-priced telegram and the two-cent stamp, of which over one hundred millions of dollars worth are used yearly. The argument of the telegraph companies has been that telegraphing is an emergency business. People only use it when compelled to and then are willing to pay the price. This position is in strong contrast with every other art or industry, and must surely give way to a more enterprising policy, and all correspondence of any importance whatever will be telegraphed. Words will go by wire instead of by train.

To restrict the use of a wire by working it at from nine to forty words a minute when it is capable of carrying 1000 words, is wasteful.

To put a letter in a bag, cart it to the train, haul it a thousand miles, and then cart it to the post office, is slow.

Between these two methods of communication, it is thought there is room for the Telepost.

NOTE.—During the lecture 100 words per minute were transmitted by the Electro-Magnetic Automatic System and reproduced in perforations on a tape at the receiving station over an artificial line representing 500 miles. The reproduced tape was then put in a local sounder circuit and the message ticked off in perfect Morse at speeds ranging from ten to sixty words per minute.

By the rapid Automatic System 1,000 words per minute were transmitted over the same circuit and plainly recorded in Morse characters on a tape.

SAFEGUARDS FOR MINES.

The coal mine death roll in Pennsylvania during 1906 was 500; 250 died as the result of gas or dust explosion. In West Virginia in the same year mine explosions cost 88 lives, and in the early months of 1907 the list of fatalities was increased by more than a hundred more.

That the United States is far behind European countries in safeguarding the lives of its miners has already become evident from the investigations now being carried on under the direction of J. A. Holmes, of the United States Geological Survey; but determined efforts are now to be made to bring about better conditions at the coal mines, to stop the appalling sacrifice of human life, and incidentally to lessen the waste of fuel in mining operations.

A series of unique experiments is about to be undertaken by the fuel division of the Survey, with a view to determining the safety of the various dynamites and powders used in blasting in the presence of the deadly firedamp and perhaps equally deadly coal gas. The explosives which stand the severe tests for which plans are being made will be classed as "permissible explosives," and their use will be urged upon the mine owners of the country.

The experimental station which is to be established as the basis of the proposed tests will be under the direction of Clarence Hall, the explosives agent for the Government. Mr. Hall has recently returned from England and Belgium, where he examined the splendid experimental stations that have there been maintained for years. In these and other European countries the miners, the government, and the manufacturers of explosives coöperate in the effort to prevent such casualties as those by which this country has recently been horrified. The English experiments have resulted in

establishing a number of "permissible explosives," whose use by the miners is compulsory. English miners are also restricted to a limit charge, for exceeding which a severe penalty is imposed. In the coal-mining States of this country protective regulations for the use of blasting materials are few, and in many States no attempt is made to control the kind of powder used.

The experimental station in Belgium was intensely interesting to Mr. Hall, the gases used in the tests coming from an abandoned mine. In a test of safety lamps witnessed by Mr. Hall at this station the lamp most generally used in the mines of the United States behaved the worst, igniting the gas each time. A self-igniting lock lamp made in Germany proved the best.

Another line of investigations to be carried on by the Survey will relate to rescue work. It is declared that in serious gas explosions in mines many lives could be saved were it possible for the rescue party to enter immediately after the accidents. As it is now, the deadly fire-damp often holds the men back for hours while their comrades are slowly being suffocated or burned to death. At the Belgium station Mr. Hall found an apparatus capable of sustaining life in the midst of fire-damp or among the poisonous vapors that follow mine explosions. The apparatus will be tested in the miniature coal mine which will be fitted up as a part of the experimental station, and if the tests are successful its use will be strongly urged.

It will not be possible, of course, to compel the adoption of safety regulations or appliances; but miners and operators will be invited to witness the tests, and the results of the investigations will be given to the public in the hope that great good may follow.

The location of the experimental plant has not been definitely decided on, but it will probably be in the Pittsburg district, and Mr. Holmes states that the work of erection will be begun within a few weeks.

TWO WATERS FROM ONE WELL.

A flowing well from which both fresh and sulphur waters are obtained—one of the wonders of Logansport, Ind.—has recently been visited by a member of the United States Geological Survey who is making a systematic study of Indiana well waters.

The well is in Riverside Park and was drilled by the city two years ago. An eight-inch pipe was sunk to a depth of eighty feet, and inside of it a five-inch casing was placed. Fresh water from a bed of limestone comes up between the two pipes, and water which tastes and smells strongly of hydrogen-sulphide gas comes up through the five-inch pipe from a lower stratum in the limestone. The sulphur water flows with a volume of about a gallon a minute from the drinking fountain, while the fresh water flows with a somewhat smaller volume from the pipe about twenty feet away. Thus the visitor to the park can have his choice of drinks. Samples of both waters were collected by the geologist and shipped to the laboratory of the Survey at Washington, D. C., for analysis.

The only similar well known is situated about fifteen miles north of Cincinnati, Ohio, but the Ohio well is non-flowing.

Working Standards of Light and Their Use in the Photometry of Gas.

(Paper read before the Franklin Institute, January 9, 1908.)

By Chas. O. Bond.

This paper will deal with such standards only as are generally used in testing the illuminating value of gas produced in this country.

It is well first of all to define clearly what is meant by the Unit of Light as understood by gas people. It is the average light, measured in a horizontal direction given by Parliamentary sperm candles prescribed by the British Metropolis Gas Act of 1860, said candles to be six to the pound and burning 120 grains per hour. This, of course, would not refer to one candle but to the average of many candles; for candles differ in light giving value over a considerable range. This Unit, it is clear, could not be definitely set aside for reference until there appeared a light source of sufficient constancy to be competent to preserve this Unit when once its value had been incorporated in that source.

The first lamp which undertook this office was the Pentane Air Gas Flame, devised by A. Vernon Harcourt, this flame being maintained as seen by the screened eye at a constant height of 63.5 mm. and the fuel supply coming from a definite mixture of air and pentane vapor contained in a small holder. This flame was naked, of approximate shape of the candle flame and received its fuel without the intervention of a wick. Furthermore, its value through height regulation had been so adjusted as to give a light exactly equal to the average of many candles. This is an important point, for in later years when the effects of atmospheric changes upon the various flames were studied, it was seen that these two flames being so similar, would be nearly if not quite equally affected.

The London Board of Trade Committee on Photometric Standards, appointed in 1891 and reporting in 1895, were so confident of the worth of the Pentane Air Gas Flame as to state:

"5. We find that the one candle light flame proposed by Mr. A. Vernon Harcourt as giving a standard light and commonly known as the 'Harcourt Pentane Air Gas Flame,' when used under the conditions defined, does constitute a very exact standard, capable of being reproduced at any time without variation of illuminating value.

"6. We have satisfied ourselves that the light given by Mr. Harcourt's above mentioned pentane air gas flame as defined, in respect to the conditions of its production in the Appendix (Sec. III) is a true representative of the average light furnished by the sperm candle flame constituting the present standard." * * *

The elaborate determinations covering a period of thirteen years over which this pentane air gas flame had been tested against the average candle and from which the Board of Trade Committee satisfied themselves were as follows:

Date.	Observers.	Value of air-gas flame in standard candles.
1879	Vernon Harcourt	.994
1879	Livesey and Brown	.990
1881	H. B. Dixon	.998
1887	British Association Committee	1.016
1888	British Association Committee	1.006
1891	Greville Williams	1.008
1891-2	H. B. Dixon	.998
	Average	1.001

These facts and quotations are cited because it has been the custom for the illuminating gas industries of this country to follow the methods set by the London Gas Referees, especially in photometric affairs. So that, while in 1895 the Unit of Light still officially resided in the average sperm candle, there existed another source where one could go and obtain its value far more readily. Yet this air gas flame with its attached holder lacked the portability of the candle, and so another effort was made to place the Unit in safe but portable keeping. Mr. Harcourt proved to the satisfaction of the Referees that he had devised such a lamp in 1897, called the Ten Candle Pentane Lamp, and the Referees adopted it at the assigned value of ten standard candles.

If custom is to be followed, therefore, the Unit of Light as understood to-day by the illuminating gas industries of the United States is one-tenth of the Harcourt Ten Candle Pentane Lamp. There are in use in this country to-day over 150 such lamps, or American reproductions of them, and their use is extending rapidly. It is a good indication that the American gas industries desire a more intimate acquaintance with the Unit, in order that more accurate photometry may result.

Standards of light are of three kinds: Primary, secondary and working. A primary standard is one that may be built and operated from a written specification. The chief quality desired is reproducibility, even if this has to be attained by infinite pains and for a short time only.

A secondary standard, once calibrated against a primary standard, must have the quality of constancy. It should also, if possible, be inexpensive, portable, and easy to set up and operate, but not necessarily reproducible.

A working standard, as its name indicates, should be one adapted to the work in hand. It may be calibrated as often as desired or as is necessary.

Until recent years the gas industries of this country largely used the candle for each of the four purposes defined above; it was Unit, primary, secondary and working standard all in one. And it may be said that the nearer a standard can come to fulfilling all these conditions accurately the more ideal it will be, except that the Unit is small for practical measurements.

With the exception of Violle's suggested primary standard, which is the light emitted from a square centimeter of molten platinum at the temperature of solidification all the other feasible primary standards have depended upon incandescent carbon for their luminosity. This carbon may be in a fixed position and rendered incandescent by the molecular agitation produced through an electric current, or it may be in a free stream gaining its luminosity through the application of heat as in flames.

The attempt to preserve luminosity constant in flame standards is made in either of two ways: (1) by a uniform consumption of fuel, or (2) by the maintenance of a constant flame height. Granted a fuel of definite composition either of these methods would probably succeed were it not for changes in the atmosphere supporting flame combustion. The luminosity of the carbon

particles, and consequently of the flame, is said to vary as the fifth power of their absolute temperature. Changes in the atmospheric component of the gaseous fuel mixture will therefore produce variations of flame temperature and hence of luminosity.

So that, with the greatest care in specifying the construction, operation and fuel for these primary standards of the flame type it has not been possible to secure the reproducibility of a given light value to within less than a range of three per cent. The Reichsanstalt in Germany will certify lamps (Hefners) that come within two per cent. above or below as regards their light value as compared with that of the standard lamp.

Out of sixty-four pentane lamps that have been standardized by the Photometer Department of the Philadelphia Gas Works eight have fallen more than one and one-half per cent. from the normal as compared with an imported English Pentane lamp certified by the Secretary of the London Gas Referees, and three of these were found to have done so through faults in construction. As indicative of the constancy of pentane lamps upon intercomparison I will cite an instance: English Lamp, No. 51, was imported from London in January, 1900, having an ascribed value of 10.0055 candles, sealed and certified by W. J. A. Butterfield as compared with one of the lamps proved by the Referees to give a value of ten candles. On May 13th, 1904, this English lamp 51, (value 10.00) imparted a value of 10.04 to American lamp No. 2 as an average of sixty readings. On May 17th, 1905, American lamp No. 2 (10.04) imparted a value to American lamp No. 89 of 10.02 as an average of 100 readings.

In the summer of 1907, this American lamp No. 89 was taken to London, its value being unknown to the London Referees, and it was compared with one of their proved lamps of ten candle value. Upon this test American lamp No. 89 had ascribed to it a value of 9.99 candles as against the above-mentioned value of 10.02, which it bore from calibration on this side of the water. This is a remarkable agreement, there being a discrepancy of only 3/10ths of one per cent.

It is apparent that the pentane lamp has the quality of constancy and is therefore able to act as a vehicle in conveying a given value to any of our working standards in gas photometry. Being constant for a given atmospheric condition, the original lamp in London may also be depended upon to maintain accur-

ately the Unit of Light value. From these two considerations we see that it is now possible by means of good working standards to measure the quality of our gas in terms of the true English Unit of Light.

We will now consider the qualities which should be possessed by the ideal working standard and then proceed to the discussion of those working standards which are in general use in America. These requirements are:

1. That it should be readily portable, of simple construction and operation, and of unvarying dimensions.

2. It should have an independent fuel, reasonable in price and readily procurable, of definite chemical composition with a fixed boiling point.

3. The flame should be of the same order of luminosity as the test flame; of a similar color; fed without a wick; at a constant pressure, through a constant opening; and no chimney should intervene between it and the photometer disc.

4. The lamp should be burned in a quiet, adequately ventilated room of uniform temperature and be supplied with pure air of the same temperature. After reaching thermal equilibrium its flame height should be set and all the conditions named above having been complied with, the flame height and flame value will remain unchanged for that particular atmospheric condition.

5. It is known that all flames being supported in combustion by atmospheric oxygen are influenced by the condition of that atmosphere as regards carbonic acid content and water vapor content. It is desirable, therefore, that the luminosity of the standard used should, as far as possible, be intleunced in the same direction and to the same extent as the test flame. In this way the correction in value is automatic.

COMMON WORKING STANDARDS.

Reports were received by the American Gas Institute from the gas companies in about eighty of the largest cities of the United States, showing the following working standards to be in use:

A. British candles of several importations. Used by thirty-one of the forty municipal and state inspectors, and by forty-one gas companies.

B. Edgerton Standard, used by eighteen gas companies; no municipal or state inspectors.

C. Hefner lamps, used by one municipal inspector; five gas companies.

D. Electric incandescent lamps, used by two municipal inspectors; no gas companies.

E. Elliott lamp, used by eleven gas companies.

F. Pentane Lamp, used by thirty-one gas companies and three municipal inspectors.

G. Jet Photometers, variously manipulated, used by twenty-eight gas companies, twenty of which also use bar photometers.

Of these working standards we may eliminate from consideration D (electric incandescent lamps) and G (jet photometers); D because no companies use it and for the reason that it is unaffected by atmospheric changes and so is unsuited for testing gas flames which *are* so affected; G for the reason that while by flame phenomena it serves to indicate the direction of change in candle power and can be calibrated fairly well, yet in the true sense it is not a photometer and makes no use of the light standards under discussion. In justice to the electric incandescent lamp it should be said that it is to-day the most trustworthy custodian of the Unit of Light, and is employed at the Bureau of Standards for that purpose.

A. *Candles.* As a working standard these have back of them the weight of long usage, of being mentioned in many contracts, and of general adaptability. They are still in the lead, numerically, as a standard. They possess a light of correct color, they are cheap to transport. This is all that can be said in favor of them as a working standard. There is no doubt that the name "candle power" has had much to do with their retention. In single determinations, which is the function of a working standard, they do not prove constant. Hence, gas companies must allow a safe margin for their vagaries. Their average variation above and below normal as thoroughly observed by the Dutch Photometric Commission was 2.87%, and individual variations were over 9% above and below normal.

Furthermore, the users of candles in this country are now in an anomalous position. One requisite in the past to make a candle of official value was that it should be certified by the London Gas Referees. For several years now the pentane ten candle lamp

has been the official standard in England and it is not likely that the Referees are still certifying candles; yet we import them and trust to their being made in accordance with specifications. The last specifications for the purpose of securing uniformity in their manufacture were issued in 1894 and these were so minute that they have rarely been complied with by the manufacturers.

Not only is the candle specified,—its weight, buoyancy, composition, material, wick, method of plaiting wick, its ash by weight after burning, melting point of sperm, etc.,—but a rigid method of burning them is laid down. In the warmer and more humid parts of this country it is next to impossible to comply with these regulations for burning them. They are particularly susceptible to the influence of moisture in the air, and in the warm days of last summer we made the attempt to put this humidity influence in the shape of a formula.

For Philadelphia, using the short candle of the "B.T.S." brand, we would say, Candle Power $= 1 + .0087\ (9.3 - e)$, where 9.3 litres of water vapor per cubic meter of dry air is normal, and where "e" represents litres found present. It is not expected that this formula can be applied to individual readings, but only to averages of a considerable number.

Mr. H. G. Bishop, of Baltimore, has furnished me with data concerning the grains of sperm consumed in ten minute intervals, extending over a period of eight years and averaged by months. This shows the effect of humidity very well.

Jan.	40.08	Feb.	40.07	Mar.	40.42	Apr.	40.55
May	40.42	June	39.18	July	38.77	Aug.	38.62
Sep.	39.46	Oct.	39.94	Nov.	39.82	Dec.	40.05

These are the results from large averages, running from 120 to 235 determinations in each monthly classification, so that all wide variations are smoothed out. The normal consumption of sperm for a ten minute interval is forty grains, and readings are discarded where the sperm consumption varies more than five per cent. from the normal. As seen from the above figures the average consumption for the month of August is 3.5% below normal; so there must have been days, even in latitude 40° North, when it would have been impossible to secure a determination using candles if they had burned in normal accordance with humidity conditions. It would be rather discouraging to try all day for a

correct determination of candle power with the certain knowledge that if the humidity did not decrease none could be obtained. The remedy would seem to lie in enlarging the limits of permissible variation from the forty grain rate. But as the case stands, if the candle is accepted for a working standard the method of its use must be accepted also.

Candles imported from different sources differ in value, this difference being in some cases as much as seven per cent. The number of threads per strand of the wick differ, the melting point varies, the curvature of the wick during burning has an important bearing on the luminosity of the flame, its temperature being affected.

In spite of these damaging facts many people have an abiding faith in the accuracy of these candles as a working standard, and when in comparison with some other standard there occur irregularities, they are quick to attribute them to the other standard. In order to cover this phase of the argument I selected from thirty boxes of candles one candle each, and, arranging them in pairs, tested the fifteen pairs against each other in a comprehensive manner. In this way I obtained the average relation existing between the pairs and found that the highest variation above this was 11.5% and the lowest was 7.5% below. It is plain, therefore, that the fault lay in the candles themselves.

Finally, it cannot be claimed that the manipulation of the candle in making the determination of illuminating value is either simple or easy. There is the trouble of cutting it in two and waiting for the cups to form properly; its adjustment of flame axes to a correct position and distance from the light under comparison, for the wicks twist about as they unbraid; the nice adjustment of the balance and the anxiety of watching for it to turn; the flickering of the flame caused by the minutest draft; the necessity of raising the candles in their holder as they are consumed.

For the reasons enumerated above it is difficult at this time to justify the use of candles as a standard of light except when the average of a great number of determinations is used; or when little accuracy is required; or when the place of test is so remotely located as to make other standards not feasible, or else legislative or contract obligations force their use.

B. *The Edgerton Standard.* This is a development from the Methven screen, much used in England as a secondary standard.

Methven claimed that if a coal gas flame burning in a Sugg D Argand burner was kept at a constant height of three inches, there was a zone in that flame which was of great constancy and brilliancy. He erected a screen about $1\frac{1}{2}''$ in front of the axis of this flame containing, at the height of this zone, a slit about 6 mm.

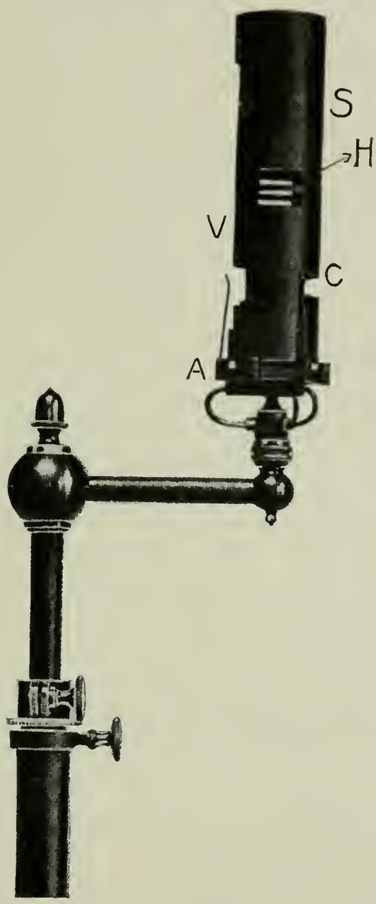


Fig. 1. The Edgerton standard.

wide and 25 mm. high, through which a light of two candles was supposed to issue.

The Edgerton Standard burner consists of a Sugg D Argand burner, with a $7'' \times 1\frac{3}{4}''$ chimney surrounded by a blackened brass sleeve. In the front of this sleeve with its lower edge $\frac{7}{8}''$ above

the top of the steatite ring of the burner, there is cut a slot 13/32″ high and of such width as to include the entire diameter of the flame. The theory of the standard is, that if the flame be adjusted to a height of three inches the horizontal section visible through this slot will remain practically constant in candle power for ordinary variations in the illuminating value of the gas supplied to it. The sleeve in the rear of the flame is also cut away so as to prevent interior reflection from it, and small side slits are cut in the sleeve at the proper height to observe whether the flame is kept constant at three inches height.

Edgerton seems to have made an improvement on the Methven Screen in having his slit disclose the entire diameter of the flame instead of only partially doing so; for the radiant center of the Methven standard is not in the plane of the slit, nor does it lie at the geometrical center of the flame, but it changes for each change in the distance of the photometer disc from the standard.

If, in using a screen through which a standard light is to issue, the aperture be made very small the radiant center of the light may, without appreciable error, be considered to lie at the slit. If, however, the aperture be somewhat enlarged, and if the photometer disc be placed quite near, as it would be with the light of only two candle value given by the Methven standard, then as the disc was moved closer the dimensions of the section of the flame exposed would increase both horizontally and vertically.

In the case of the Edgerton standard the whole diameter of the flame is exposed, and the only increase in sectional area would be in a vertical direction. Also, as this standard gives more than twice the light of the Methven, the error from this cause would be reduced by the greater distance of the photometer disc. As a matter of fact experiment has proved the radiant center of the Edgerton standard to lie 9/10″ in front of the geometrical center of the flame, and the same result was deduced by formulæ worked out by Prof. Jacobus, of Stevens Institute.

In using the Edgerton, therefore, its geometric center is placed 9/10″ back of the usual standard line, and it is standardized in this position.

Some experiments showing the light value of the Edgerton Standard under different conditions are detailed in a paper by Mr. Rollin Norris, published in the 1899 Proceedings of the American Gas Light Association. The fuel supplied to this

standard was either straight coal gas or straight carburetted water gas, but not a mixture. When water gas was used, the value of the Standard varied from about 5.70 to 6.30 candles; when coal gas was used of a candle power as shown on a flat flame burner as being between 13 and 17, the value of the Edgerton varied from about 4.20 to 4.60. It is evident that a mixed gas would give values, uncertain with varying proportions of the mixture, falling between those figures.

When water gas was used there seemed to be no fixed relation between the candle power of the fuel supply and the value of the standard resulting; when coal gas was used there was an increase of about 1/10th candle in the value of the Standard for each candle increase in the value of the gas supplied. The effect of variations in the flame height may be seen from the following data:

Height of flame in inches	2.5″	2.75″	3.00″	3.25″	3.50″
Average C.P. of Edgerton Std.....	6.52	6.42	6.31	6.21	6.11

Mr. Norris concludes that with either coal gas or water gas, if the Edgerton be carefully standardized for the conditions under which it is to work it may be relied upon to give results whose error does not exceed 1½ candles, while a large majority of the observations will be correct to within one candle of the true value of the gas.

In the use of this standard it is imperative that the chimney shall be kept clean and that the calibrated section of it be always presented to the opening in the screen. As the sleeve completely surrounds the glass chimney the latter gets much hotter than if it were exposed to the air, and if by neglect the flame lengthens for a time so as to fill the chimney, it is likely that the glass will be melted down.

The simplicity, ease of operation, cheapness of maintenance, and rapidity of preparation of this working standard have in the past made it very popular about gas works. It has been valuable in direct proportion to the care taken to make and keep it accurate. Many works have it in position and standardize it frequently from a pentane lamp. If coal gas can be furnished to it through an averaging tank to prevent large and rapid changes in the quality of the gas, it forms a valuable adjunct to the operating department.

C. *The Hefner Lamp.* This standard is little used in America

among gas companies, and personally I am not as yet familiar with its operation. Without doubt this lamp has been described before this Institute already. The literature relating to it is full; it has been more thoroughly investigated than any other light standard, and is the equal in reproducibility of any of them. It is simplicity itself, and readily portable. The greatest credit is due to those scientists in Germany who have perfected its construction and method of operation. Yet there would seem to be good reason for its non-adoption as a *working* standard in America. It is, first of all, a Primary standard of light, that standard being the German Unit and not the one which we follow. It has a value even less than that of our candle, being about 9/10ths of it, and our candle used singly is too small for working purposes.

With a magnifying flame gauge the Hefner flame height is set at 40 mm., for the lamp is constructed to be normal at a stated height of flame and not for a stated consumption of fuel. This height is difficult of attainment, for the flame tip is very pointed, and eyes differ in its observation; an error of 1 mm. in flame height causes an error of 2.5% in the light emitted. The flame, moreover, is of a distinctly reddish color, less suited to match the gas flame in disc comparisons than is the candle flame. It is very sensitive to drafts; more so probably than candles on account of the obstruction which its base presents to a vertical flow of air currents to the flame; and as accurate flame height is the great desideratum this objection becomes more important than it otherwise would be.

The lamp is operated with a wick, which is adjustable in height and which supplies the fuel, amyl acetate, to the flame.

E. *The Elliott Lamp.* This lamp was contrived by Dr. A. H. Elliott, of New York City. It is the adaptation of the student lamp principle to the purposes of a secondary standard, the fuel used being a high grade of petroleum, usually Pratt's Astral oil. The wick is flat, and a screen is placed close beside the flame with an opening of the requisite dimension to permit the passage of a ten-candle light to the disc. The glass chimney is large, round and bulbous so as to allow the presence of the screen inside it without undue deflection of air currents. The screen being placed so near the flat flame and its opening being of relatively large size, the standard does not require a similar correction for radiant flame center as does the Edgerton Standard.

The lamp is painted black, and has an acorn-shaped reservoir capable of holding about 500 c.cs. of oil and the rate of consumption of oil when burning normally is about 1 c.c. per minute.

The wick is $1\frac{1}{2}''$ wide, and instead of being trimmed horizontally across its entire top, the two corners are cut diagonally, leaving a horizontal top of $1''$. This has the effect of producing a flame with a level top and vertical edges. A tin form is supplied which fits snugly over the end of the wick, indicating the direction of trimming. The trimmed end is then lightly touched with a flame while still dry, to singe off the unevenness and fluff occasioned by the scissors. The wick is then placed in position and run up and down the channel its whole length to make sure it works freely. The reservoir is then filled and after about five minutes the wick is saturated and ready for lighting.

The burner is provided with an extra high dome through which the flame issues, and to this dome is attached a screen, consisting of three parts: two uprights at the sides with a space of $1\frac{1}{2}''$ between them, and an adjustable plate connecting them above. This plate is four inches high and its lower edge is set at a height of about $\frac{7}{8}''$ above the center of the dome. The screen is made adjustable in a vertical direction so as to permit an increase or decrease in the exposed length of flame necessary to produce ten candles.

The lamp having been lighted and chimney placed, the wick is then turned up until the opening in the screen as observed from the photometer disc is a luminous whole with the exception of the blue flame at the bottom. Right here the greatest care must be observed to get a level topped flame. After burning twenty minutes so as to gain thermal equilibrium the lamp is ready for standardizing and subsequent use. It should not be touched again, and it will continue to give a remarkably constant light until the reservoir is depleted. If exactness in the preparation and manipulation of the wick is observed the lamp is fairly reproducible at ten candles for a limited time. It is claimed that a wick will last about 200 hours before capillarity is impaired, but the usual errors incident to the use of the same are soon encountered, and the safest method is to standardize the lamp frequently.

Following are light values obtained over a considerable period for the Elliott lamp as compared with a pentane lamp, the above method of adjustment being used:

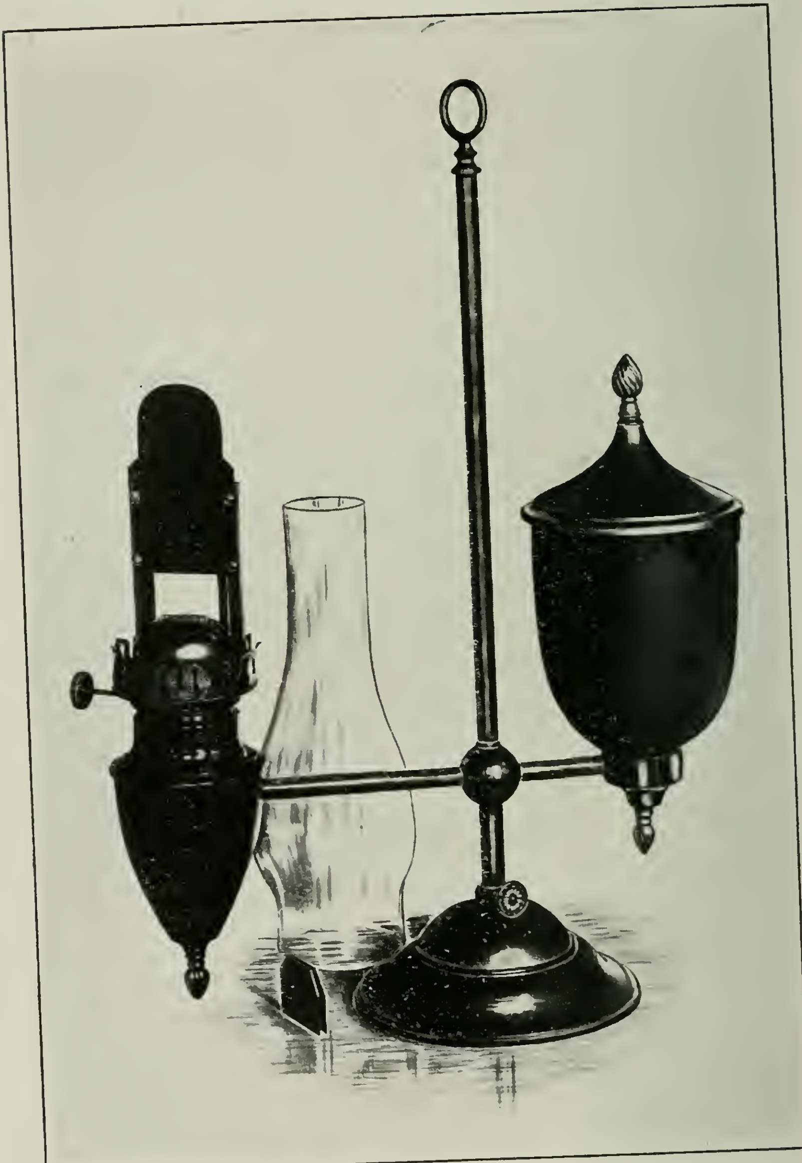


Fig. 2. The Elliot lamp.

Date.	No. Readings.		Value.
3/23/'07	11		9.945
3/25/'07	18		10.044
3/26/'07	36		10.292
3/27/'07	16		10.194
3/28/'07	36		10.11
	117	Avg.	10.117

Another series of readings was begun on April 17th lasting until April 23d, a total of 550 readings being taken, and the average value given the lamp, the positions of the contrasted lamps being reversed half the time was 9.957. The lowest value was 9.76 and the highest value was 10.21.

An experiment to determine the error introduced by disturbing the height of the flame was made:

	Correct height.	¼″ low.	¼″ high.	½″ high.	Correct height.
Value vs. pentane lamp.....	9.922	10.172	10.647	11.243	9.831

This shows most forcibly the necessity of having the wick so trimmed as to have a level top to the flame for accurate adjustment. If such care is given the lamp it may be classed as equal to the Edgerton Standard (with the further advantage of having an independent fuel supply) and as better than the candle for secondary work.

During the summer of 1907 the Elliott lamp and the pentane lamp were subjected to the influence of vitiated atmosphere in a closed room. The loss in illuminating value was attributed in each case to vitiation, though of course by the use of proper apparatus it would have been possible to separate the effect of the carbonic acid, the water vapor and the diminished oxygen effect. In reality these effects are always present together and it would seem that the inclusive term "vitiation" is more proper, and that the CO_2 content is a fair measure of it.

In these tests the Elliott lamp and Pentane lamp having approximately the same value, suffered about equally for a given per cent. of vitiation, while the candles suffered much more.

F. *The Pentane Lamp.* While something has been said of this lamp under the discussion of the Unit and Primary standards, it is proper that an instrument of its importance in the world of

physics should be accurately described, both in construction and operation. I quote from W. J. A. Butterfield's extract of the Referees' Method:

"Air is saturated with pentane vapor by passage through a saturator, which is about two-thirds filled with pentane, and the air gas so formed descends by its gravity to a steatite ring burner. The saturator is 184 mm. square and 38 mm. deep, and contains seven partitions soldered to its top, and alternately meeting either side and stopping 25 mm. short of the opposite side. The air is thus compelled to pass eight times across the saturator. A piece of India rubber tube, 13 mm. wide internally, conveys the air gas from the saturator to the burner. The air inlet pipe to the saturator, and the air gas outlet are provided with stop cocks, and the height of the flame is controlled by the outlet cock. A brass chimney 431 mm. long, 30 mm. inner and 32 mm. outer diameter, is placed so that its lower end when cold is 47 mm. above the steatite burner. This chimney tube draws the flame to a definite form, and hides the top of it from view. A mica window in the tube allows the tip of the flame to be seen, and the height to be regulated, so that the tip is somewhere between the bottom of the window and a crossbar. A tube, 290 mm. long and 50 mm. inner and 52 mm. outer diameter, surrounds the chimney tube, and draws in air at its base. The chimney tube projects 65 mm. below and 76 above this outer tube. The heated air passes from the top of the outer tube to another tube 529½ mm. long and of 23 mm. inner and 25 mm. outer diameter, which is placed parallel to the first tube, and with its axis 67 mm. distant from the axis of the latter. From the bottom of this tube the air passes to the center of the steatite ring of the burner. The outer diameter of this ring is 24 mm., the inner diameter 14 mm. and there are 30 holes, each 1.25 mm. in diameter. A conical shade 102 mm. wide at base, 55 mm. wide at top, and 57 mm. high, having an opening 34 mm. wide, is placed around the flame. The light which serves as the ten candle standard passes through the opening in this shade. Levelling screws are provided, by which the lamp is adjusted until it is vertical, and the height of the steatite ring (when using the Table Photometer) is 353 mm. from the table."

The American lamps differ from the English in details, but not in essentials. They have a metal tube instead of an India rubber tube to convey the pentane vapor from the saturator to the burner,

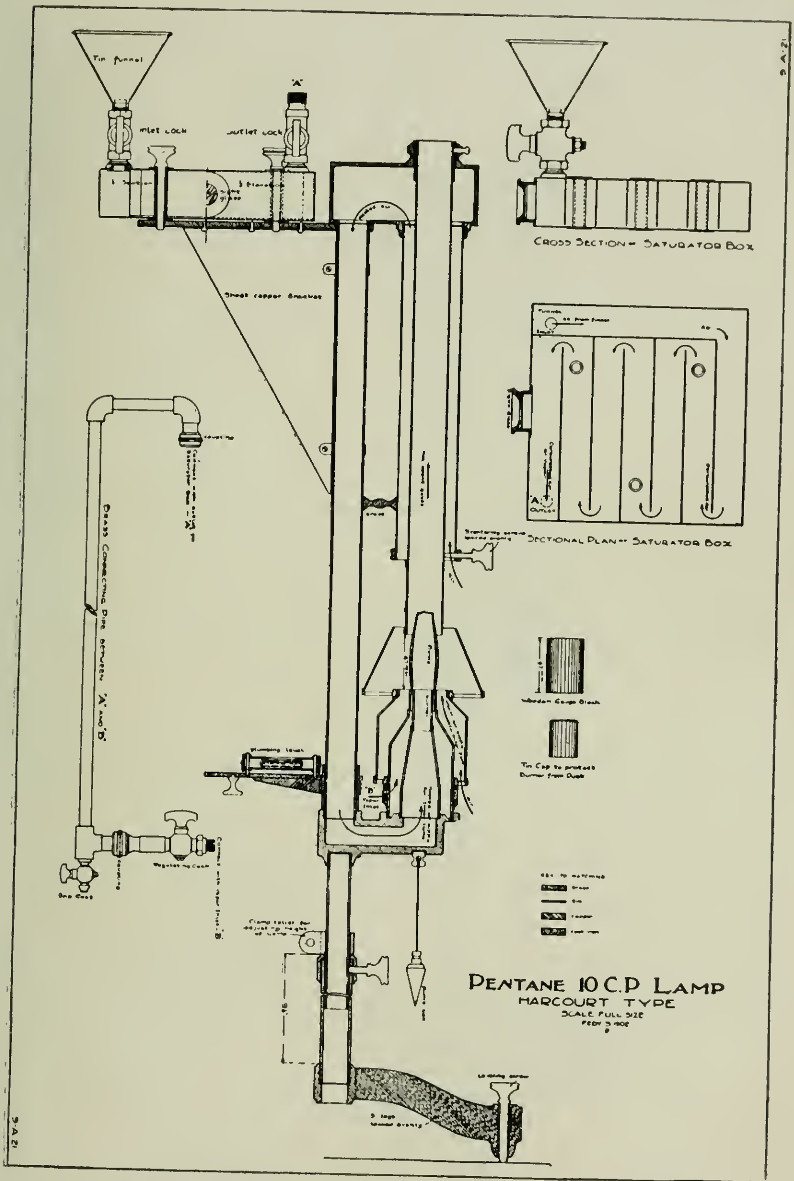


Fig 3. Sectional view 10 c. p. Harcourt Pentane lamp, American make.

as it was found that the pentane had a solvent action on the rubber. The vapor tube is also provided with a waste cock from which condensed vapor may be withdrawn if necessary; with a regulating cock capable of nice adjustment. It has a lower position for the cross bar in the mica window, American practice being to regulate the flame height with the top of the flame at this cross bar, while English practice regulates at a position midway up to their higher cross bar. The chimney centering screws of the American lamp are threaded through a split collar at the base of the outer chimney, and a stiffening band is placed around the inner chimney upon which the ends of these screws touch. This is to prevent indentation of the inner chimney by the screws as they lengthen by heating. The American lamp is made in such a manner that the burner is removable. The saturator box is fixed in position by three screws instead of being loose upon its support. The lamp is provided with a leveling platform, and with a plumb-bob directly beneath the burner center. The American lamp is heavier, due to the use of light brass castings in some positions instead of sheet work. The dimensions of the two lamps are identical, however, and after each has reached equilibrium, they are in very close agreement as stated earlier in this paper.

FUEL.

The fuel supplied to this standard lamp is prepared as follows: Light American petroleum, such as is known as gasoline and used for making air gas, is to be further rectified by three distillations, at 55°C., 50°C. and 45°C. in succession. The distillate at 45°C. is to be shaken up from time to time, during two periods of not less than three hours each, with one-tenth its bulk of (1) strong sulphuric acid, and (2) a solution of caustic soda. After these treatments it is to be again distilled, and that portion of it to be collected for use which comes over between the temperatures of 25°C. and 40°C. It will consist chiefly of pentane, together with small quantities of lower and higher homologues whose presence does not affect the light of the lamp.

TESTING THE FUEL.

The density of the liquid pentane at 15°C. should not be less than 0.6235 nor more than 0.626 as compared with that of water

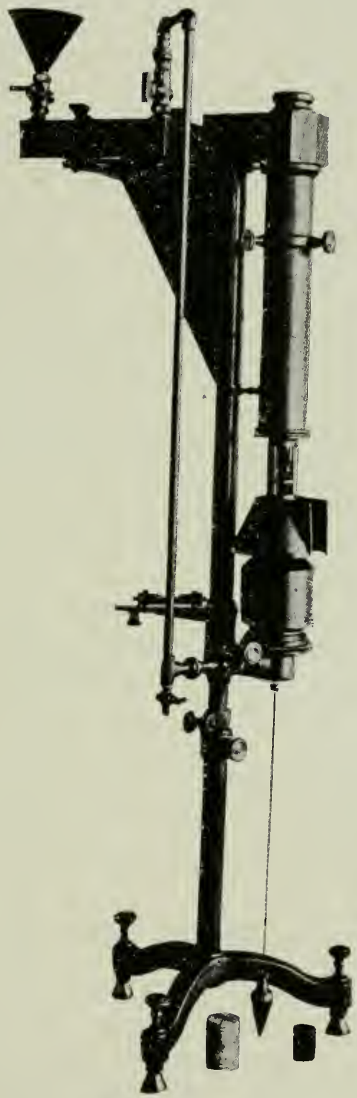


Fig. 4 American Pentane lamp.

of maximum density. The density of the pentane when gaseous, as compared with that of hydrogen at the same temperature and under the same pressure, may be taken. This is done most readily and exactly by Gay Lussac's method, under a pressure of about half an atmosphere, and at temperatures between 25°C. and 35°C. The density of gaseous pentane should lie between 36 and 38, hydrogen being taken as 1.

Any admixture with pentane, of hydrocarbons belonging to other groups and having a higher photometric value—such as benzene or amylene—must be avoided. Their presence may be detected by the following test: Bring into a white stoppered glass bottle of from 80 c.c. to 100 c.c. capacity, 10 c.cs. of nitric acid, spec. grav. 1.32 (made by diluting pure nitric acid with half its bulk of water). Add a few drops of a dilute solution of potassium permanganate, sufficient to give to the acid a full and permanent pink color. Pour into the bottle 50 c.cs. of the sample of pentane, and shake strongly from time to time during five minutes. If no hydrocarbons other than paraffines are present, the pink color, though somewhat paler, will still be distinct. If there is an admixture of as much as ½ per cent. of amylene or benzene, the color will have disappeared.

This fuel is very volatile, requiring the tightest of cans for storage, and the storage place should be kept cool. When burning in the lamp it gives a soft, white flame, especially adapted in color to gas testing. The lamp must not, of course, be filled while lighted, or when a flame is near. It requires about fifteen minutes to reach its thermal equilibrium, if the room be not too cold, when the flame may be adjusted and it will remain at a constant height. The room should be evenly ventilated to secure this result. One pint of pentane is sufficient for six hours burning at normal height.

While putting pentane into the inlet funnel of the saturator, the outlet cock and waste cock will be kept open for a vent, but the regulating cock will be kept closed to prevent the accumulation of vapor and its condensate in the base of the burner. After filling close all cocks. When lighting, open first the waste cock, then the outlet cock, when the pressure in the saturator will be released and any waste vapor or air in the vapor tube will be discharged below the burner level. Then open the inlet cock, close the waste cock, and holding a lighted match over the burner,

gradually turn on the vapor stream by means of the regulating cock. If any condensation has formed in the base of the burner, the first ignition will show a pointed blue flame playing lazily at the center of the burner. As the air supply increases this will turn to a greenish color and a small sharp explosion will result. The regulating cock will then be opened gradually until a proper ignition ensues, indicated by a steady, white, well-formed flame.

There cannot be two opinions by those who know, as to which of the working standards above described is best adapted for gas photometry of the accurate kind. In the Philadelphia Gas Works six pentane lamps are kept in constant use, and have completely demonstrated their reliability.

As some interest attaches to the uncertain relations existing between the primary standards of England, France and Germany, I give below a table of these ratios taken from a Bureau of Standards Bulletin prepared by Dr. E. P. Hyde (1907).

Summary of Ratios of Hefner, Harcourt (10 c. p.) and Carcel:

	Harcourt / Hefner	Carcel / Hefner	Harcourt / Carcel
Reichsanstalt (using electric comparison lamp)	10.90	10.70	1.02
Laboratoire Central (using electric comparison lamp)	10.76	10.76	1.00
Laboratoire Central and Laboratoire d'Essais (direct comparison)	10.72	10.73	1.009
National Physical Laboratory (British)	10.95	10.69	1.024
Ratios computed from Bureau of Standards incandescent lamps	11.19	10.73	1.043
Best previous values (Bunte)	11.40	10.87	1.050

At the International Photometric Committee Meeting in Zurich, July, 1907, the following ratios were adopted, it being understood that the normal water vapor content for the Carcel and the Harcourt should be ten litres per 1000 litres of dry air and for the Hefner 8.8 litres per 1000.

$$\left.\begin{array}{l}\text{Carcel} = 10.75 \text{ Hefners}\\ \text{Harcourt} = 10.95 \text{ Hefners}\\ \text{Harcourt} = 1.020 \text{ Carcels}\end{array}\right\} \begin{array}{l}\text{Probable error}\\ \quad + 1 \text{ per cent.}\end{array}$$

A PROPOSED STANDARD HORSEPOWER RATING FOR AUTOMOBILES.

A standard for horsepower rating and alcohol-acetylene as a fuel was the subject taken up at the April meeting of the mechanical branch of the Association of Licensed Automobile Manufacturers. The need of a universal method for computing horsepower was discussed and suggestions for the adoption of an A. L. A. M. horsepower standard was recommended.

The horsepower of a car under the present ratings may mean anything a salesman may say, as various formulæ for computing these ratings are used, no two giving the same results. After having the advisability of a universal rating under consideration for several months the standards suggested by the branch were to be taken from a brake test at the flywheel, in conjunction with a formula to be suggested by the Test Committee. Two units were to be used, the lower being the actual rating from the brake tests, as computed from an indicator at 1000 ft. per minute piston speed, and the higher number to be the maximum horsepower developed from superior workmanship or the results of a better type motor. For example, in a 20-24-hp. motor the 20 would be the actual horsepower at 1000 ft. per minute piston speed and the 24 the horsepower which would be developed when not under normal conditions. The value of this is readily seen, as it would prevent salesmen or entrants in tests from rating a car at 30 hp. when it would actually develop 60, thereby not only misrepresenting the rating of the car, but taking an advantage of those giving an actual rating.

The discussion of alcohol-acetylene as a fuel developed some interesting matter. The growing need for a substitute for gasoline was realized, but whether acetylene and alcohol in combination would supplant the present fuel supply, is a problem yet unsolved. Mr. White, of Baker & White, exponents of the new fuel, gave a most interesting illustrated talk on the subject. Radical statements were made by him as to the efficiency of the carbide-alcohol mixture. Mr. White predicted that by September 1, alcohol could be obtained at a figure less that twenty cents per gallon, and that in certain places and in quantity carbide could be purchased for this purpose at one cent per pound. He has proved that to get the best results a half pound of carbide should be used to a gallon of alcohol, this making the cost of the new fuel slightly over twenty cents a gallon to the consumer. Every gallon of denatured alcohol contains about ten per cent. of water, which was found did not work as well as alcohol containing eighteen or twenty per cent. of water, the addition of this extra water increasing the combustion qualities of the mixture.

As engines are now built for the use of gasoline, it would be much more practical to adapt the fuel to the engine than the engine to the fuel. It seems, however, from experiments now under way, that in a short time gasoline will have one or two very strong competitors as fuel for automobile propulsion.

A business meeting of the branch followed the regular session and three new members were added to the Tire Committee to assist in the furtherance of the standardization of the tires it has adopted.—*Iron Age.*

An Eminent Inventor.

WHILE VISITING THE UNITED STATES GIVES VALUABLE INFORMATION AND SUGGESTIONS ON LIFEBOAT LOCATION AND THEIR HANDLING AT SEA.

Many of our readers have noticed that Mr. Axel Welin, of London, was present at the last annual meeting of the Naval Architects and Marine Engineers in this city, on which occasion he read a very interesting paper on one of his latest inventions, viz., "The Welin Quadrant Davit," and which paper created earnest, intelligent and friendly discussion.

Axel Welin was born in Stockholm, Sweden, about forty-five years ago, his father being private secretary to the late King Oscar of Sweden. When fourteen years old, however, he, together with several brothers and sisters, was suddenly left fatherless. After some years of hard study he passed the final examination in naval architecture and mechanical engineering at the Technical College at Stockholm. His splendid scholarship won him a position in that institution as teacher in draftsmanship. At the same time he held a position at the Palmcrantz & Nordenfeldts gun factory in Stockholm, where he made a name for himself by inventing ingenious tools for manufacturing lead bullets, shells, etc. Later on Mr. Welin was transferred to Maxim-Nordenfeldts gun factories in England, where he soon became one of its leading men. It was during those years that he invented the well known Welin breech screw for ordnance, which is now used either as originally invented or of the amended style in almost every gun from three-inch calibre up in most of the armies and navies of the world.

Later Mr. Welin severed his connection with this firm and started for himself. It was not long before he sold his various gun patents to Vickers & Maxim, in England, Krupp, in Germany, the United States Government, and others. Those who have any knowledge of the manufacture of guns are aware that he

received valuable consideration for his patents. In the meantime he invented several other useful articles of less importance, when Mrs. Welin, being of a philanthropic nature, expressed the desire that instead of inventing destructive machines her husband should utilize his brains for something to save lives. His brother being a sea captain, at that time in command of the Swedish steamship Hispania, for several years chartered by the United Fruit

Axel Welin, A. I. N. E.

Company and trading to the West Indies, drew his attention to the general unsatisfactory appliances that had so far been used for launching lifeboats on board ships.

Mr. Welin made several trips to sea, acquainting himself with the various conditions and also collecting some important data of a number of shipwrecks where lives had been lost by the hundred.

In most of these cases he found that although the lifeboats were well constructed and seaworthy, the great loss of life was in most cases caused by the difficulty of launching them on account of the operation requiring too much time and a large number of skilled seamen. In other words, in about every such accident it was the same old story—the crew could not launch the lifeboats in consequence of the rolling of the ship during which they lost control of the boats, which were immediately stove in; besides, they could only launch the boats on one side when the ship oftener than otherwise had taken a list, and not infrequently they could not launch the boats at all because the passengers, in their excitement and hurry, had filled the boats while the same rested on the chocks, consequently valuable time was lost in getting them out of the boats so that they might be launched. In the meantime the ship goes down with boats, safety appliances, passengers and crew.

Taking these dangers and their causes into consideration, Mr. Welin set to work to devise an apparatus that would meet all the requirements with the least possible complications and manipulations. His final solution of the problem is demonstrated by his invention of the Welin quadrant davit, which it can safely be said is the only patented davit that has been generally adopted by ship owners, and approved by the Board of Supervising Inspectors of Steam Vessels; and this in the short time of less than two years.

Before Mr. Welin left New York for Europe, recently, he made a tour of the United States as far as San Francisco, giving addresses at various places before such institutions as the Franklin Institute in Philadelphia, the Engineering Society in Detroit, Stanford University and the Technical Society of the Pacific Coast in San Francisco. These addresses, which were illustrated by some sixty stereopticon slides, were emphatically pronounced scientific, instructive and interesting. We hereby quote two or three items from the same, one from the superintendent of the Royal Mail Steam Packet Company, who says:

"You may run your line of steamers for fifty years without an accident, and then all of a sudden you lose one or two, perhaps more, ships in succession, and which disasters are combined with great loss of life. Then it will not help your case if you draw the public's and the authorities' attention to the fact that you can show them that you have made use of every improvement avail-

able in order to safeguard your passengers from loss of life, that argument will go a long way."

In his paper to appear next mnoth, Mr. Welin discusses the great advantage of being able to quickly swing the boats out on the high side and continues: "A further and convincing example of what may be accomplished in this direction reached me only last week in a report received from one of the foremost shipbuilding firms on the Clyde: 'Your davits on the port side had a big test the other evening. It appears that this steamer took a dangerous list. owing to the coals shifting in the starboard bunkers and to right her the boats were quickly swung out on the port side and filled with water. This had the desired effect.'" The vessel referred to is about 5,500 tons gross and is fitted with five 28-foot lifeboats on each side, and when filled with water represented a weight of seventy tons. This prompt action saved the ship from capsizing, as several others have done under similar conditions recently. The boat decks of this ship were of very light construction, and it was a surprise to the builders that in undergoing this operation they did not show any sign of weakness.

Mr. Welin has been more fortunate in disposing of his inventions than many other inventors, inasmuch as he has been able to obtain valuable consideration for his many ingenious creations, among which is the Welin quadrant davit, the patent for which he has sold to the Welin Quadrant Davit Company of New York City. The world will surely hear more of the inventions of Mr. Welin in the near future, as he is a comparatively young man, and always studying to improve that which is unwieldly and impracticable in mechanics.

As a further example of his advanced ideas we hereby reproduce a suggestion of this eminent inventor where he proposes to place the lifeboats nearer the water on the gigantic high-sided Liners now being built. Every naval architect and engineer as well as sailor can readily see the advantage of such a proposition. Take, for instance, a big steamship where the staterooms are located on from four to six different decks, the passengers on the lowest decks would consume valuable time before they could reach the lofty boat deck were it necessary to abandon the ship. One can imagine what it would mean to lower one of the boats from a deck sixty feet from the sea when it would be necessary to pay out 360 feet of rope from each davit. As proposed by Mr. Welin, the

boats would be centrally located for passengers on the upper and lower, and more convenient to those on the two intermediate decks, thereby adding to the safety of all in case boat service became necessary. Next to the value of the quadrant davit is this change in the location of the boats suggested by Mr. Welin, and we predict its early suggestion by owners and adoption by builders of new ships. The stability and buoyancy to be gained in favor of the vessel by placing these davits and enormous weight of boats so much nearer the water line would be great, besides leaving the upper decks clear of boats and gear for the benefit of the ship's passengers whose natural desire is to get as far away from the water as possible.

THE PRODUCTION OF ARSENIC AS A BY-PRODUCT IN SULPHURIC ACID MANUFACTURE.

By Edward Walker.

Until recently the arsenic removed from sulphuric acid has been wasted, owing to its production in the form of sulphide, which is not a commercial commodity. During the last year or two the United Alkali Company has conducted experiments with a new process by means of which the arsenic is recovered as arsenious acid. The process promises to be a commercial success, and in all probability will bring an important new supply of arsenic on the market, as well as make it possible to use highly arsenical ores profitably in sulphuric acid manufacture.

The process is described in a series of British patent specifications, the most important of which is No. 5151 of 1906. That the process is a success is shown by the fact that five plants are already in operation, and that arrangements are being made for building several more.

According to this process, the arsenical sulphuric acid, as it flows from the Glover tower, is first brought into contact with a reduction agent such as charcoal, in order to bring the arsenic to the arsenious state. It is then brought into contact with dry hydrochloric acid gas, the result being that the arsenic is converted into liquid arsenious chloride. This chloride is an oily liquid and a good deal of it can be separated from the sulphuric acid by settlement. The sulphuric acid drawn off from the settling tank still contains arsenious chloride. To remove the latter, air is blown through the acid. The chloride comes off as vapor, and is taken to a scrubbing tower. Here it comes in contact with water, with the result that arsenious acid and hydrochloric acid are formed. The hydrochloric acid is used over again, and the arsenious acid is collected as a commercial product. Very often, however, the arsenic contains selenium. If so, some of the arsenious chloride, which had previously separated as an oily liquid is

added to re-dissolve the whole of the precipitated oxide, and then, on addition of water, the selenium is found to be precipitated.

The process is naturally one which requires very careful attention, owing to the existence of arsenic as a volatile compound. The manufacturers and the alkali inspectors, however, speak well of the process, so it should develop into a standard method of recovering arsenic.—*Eng. and Min. Jour.*

WASTE OF ARTESIAN WATERS.

Millions of gallons of artesian waters are going to waste every day in Indiana, according to estimates made by F. G. Clapp, geologist of the United States Geological Survey, who is now investigating the water resources of the northern part of that State. Over a million gallons a day are wasted in a single county. Along Fall Creek, Lick Creek, White Run, and other streams, in the shallow valleys of which there are a great many flowing gas wells, each well pours out from five to twenty gallons of water a minute, and the amount of water thus drawn from the underground reservoirs and unutilized in Madison County alone is sufficient to supply a city of 10,000 inhabitants.

In only a few places is this water put to use. The farmers do not seem to realize that a hydraulic ram or a windmill placed on a flowing well will raise a large portion of the water to their houses on the hills above. Immense volumes of good water are therefore suffered to waste, and in this way the "head," or height of water in the wells, or the height to which it rises above the surface, has been lowered several feet. Many wells that once yielded copious and strong flows have ceased to flow entirely. By this means, also, the ground water-level in this region in ten years has been lowered over ten feet.

This loss of head, not only in Indiana, but in other parts of the country, has served to call attention to the fact that the available artesian supplies are by no means inexhaustible. Our "inexhaustible" supplies of natural gas and petroleum are rapidly being depleted, and the geologists and coal experts of the National Survey have computed with probable accuracy the date of exhaustion of our coal beds. Our "inexhaustible" forests are so dangerously threatened with speedy exhaustion that national legislation is now deemed necessary to protect them. The effect of deforestation on stream flow is at last well recognized. Since the forests of Indiana have been cut off the ordinary flow of many of the streams of the State has notably dwindled and the forest flow is far more destructive.

The conservation of the artesian water supply should not be very difficult. By simply capping unused wells, or by providing them with such means of stopping and controlling their flow, as is now applied to ordinary municipal supplies, the head of the wells can be preserved and the height of the ground water maintained somewhat near its old level. Legislation may be required to accomplish this result, yet some of the students of the matter, and among them are geologists of the Survey, hope that an intelligent understanding of the conditions will lead to practical means to check this enormous waste and its consequent immense losses in values.

Section of Physics and Chemistry.

Further Notes on Shellac. *

By Dr. H. Endemann.

In my first paper, which appeared in this *Journal's* October number, I have stated that shellac, after hydration, produces oily acids and one crystallizable acid, which I have announced to be a trioxypalmitic acid of unknown constitution at that time.

Farner states that on oxidation by permanganate in alkaline solution, azealaic acid and butyric acid are produced; this, however, I could not verify. Neither azealaic nor butyric acid is formed unless the acid is not pure but still contains some of the oily acids.

The oxidation is performed in a very dilute, strongly alkaline solution cooled by ice, to which an equal volume of permanganate solution likewise cooled by ice is added, with enough ice to keep the solution ice cold for several (2) hours. The quantity of permanganate is taken so as to represent three available atoms of oxygen for one molecule of trioxypalmitic acid; an excess of oxygen is generally taken, but this is finally removed after about six hours by the addition of bisulphite of soda. This insures the absence of trioxypalmitic acid which facilitates the final purification of the products of oxidation.

When pure acid is used for this experiment neither butyric nor azelaic acid is formed. Instead there are formed sebacic acid and δ oxycaproic acid.

It is practically impossible to separate these acids by crystallization from water, nor can the oxycaproic acid be washed out by fractional extraction with ether.

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*See this *Journal*, October, 1907, page 285.

Using the barium salts a separation can be effected.

Any unchanged trioxypalmitic acid forms a very difficultly soluble barium salt, and can thus be removed. The barium salts of the two other acids are far more soluble. Their solution is brought to dryness, powdered as thoroughly as possible, and then treated with alcohol of 95%. This dissolves the barium salt of the δ oxycaproic acid, while the salt of sebacic acid remains insoluble. The latter can be purified by heating the solution, when the sebacic salt is precipitated and can be filtered off and freed from the mother liquor by pressing.

The barium salt of the oxycaproic acid is absolutely amorphous when dried. On analysis 0.3879 gave 0.2256 barium sulphate = 0.1328 Ba = 34.29% Barium (theory 34.4) equivalent calculated therefrom = 132.5 (theory 132). A water solution of the barium salt produces a jelly with silver nitrate solution; this jelly becomes crystalline (tufts of needles) after the removal of the mother liquor. The free acid produced from this forms an anhydride on evaporation, which, however, can again be converted into the acid by boiling with baryta solution.

The sebacic acid was found to melt at 132-133°C. and crystallizes in needles. The baryta salt of sebacic acid 0.1673 gave 0.1157 $Ba\ SO_4$ = 0.0681 Ba = 40.70 Ba% theory—40.72%.

ULTIMATE ANALYSES.

			Calculated
1. *Anhydride (Lacton) δ Caproic Acid:*			
	0.143 gave..........	0.330 CO_2 = 62.93 C	63.16
		0.1149 H_2O = 8.98 H	8.77
2. *Sebacic Acid:*		Calculated 59.41 C	8.92 H
	0.1592 gave.........	0.3466 CO_2 = 59.34 C	
		and 0.1211 H_2O = 8.45 H	
	0.1533 gave.........	0.3341 CO_2 = 59.43 C	
		0.1237 H_2O = 8.94 H	
	Next analysis	59.31 C	
		8.95 H	

The formula of this trioxypalmitic acid is therefore best represented as

$$CO_2H\ (CH_2)_8CHOH.\ CH.OH(CH_2)_3\ CH.OH\ CH_3$$

which forms sebacic acid and δ oxycaproic acid

$$CO_2H(CH_2)_8CO_2H + CO_2H\ (CH_2)_3\ CH.OH.CH_3.$$

In connection with the determination of the Iodine No. or Bro-

mine number of Rosin or Colophony I have determined the Bromine No. of Abietic acid. I found that Abietic acid, $C_{19}H_{28}O_2$, requires in tolerably concentrated chloroform solution about 18 atoms of bromine, forming a body containing 57.77 bromine, and being devoid of any acid properties; from which it is evident, that the action is accompanied by a loss of CO_2. The reaction pasess off with a copious volume of H. Br. escaping. I could not test Pimaric acid, $C_{20}H_{30}O_2$, for the reason that American colophony (in distinction from many European resins) contains but little of this. Pimaric acid, as has been known for fifty years, differs from Abietic acid, and can be distilled readily, even without vacuum.

As regards my own method of analysis, I have made some changes. In the first place I find that much less sand is required than I have stated, provided the sand is very fine; 3-4 grms. are ample.

For the determination of the non-condensable rosin and oil, independent of the water soluble salts and organic matter, it is desirable to moisten the residue in the dish with some hydrochloric acid before it is extracted by alcohol. Also the residue containing non-condensable rosin is not extracted with water only but water acidified by H Cl.

From a pamphlet published by George A. Alden & Co., it appears that in the manufacture of Seedlac from Sticklack, which contains the twigs upon which the insect has grown, as well as fragments of the insects, the sticks and much color are removed after coarsely grinding and sifting, by means of flushing and washing with water and treading with the bare feet.

The lac dye, which goes into water solution, is not recovered at present owing to the advent of the cheaper coal tar colors.

The remaining Seedlac either goes into commerce and is imported into the United States as such, or it undergoes further purification by a kind of filtration and is then sold as shellac.

The Seedlacs, which reach this country and of which a series were examined, are not always pure Seedlac, but in several cases showed adulteration by rosin.*

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*Samples examined were marked respectively Taitwah, Hydrabad, Ragoon, Manbazare, Assam, Teelhar and Koosmi; also sample Koosmi prepared from Sticklac in laboratory.

In the manufacture of shellac the Seedlacs are dried and then filled into pipe-shaped cotton bags, heated over a fire and the pure shellac pressed out by twisting and then spread to cool in thin layers.

In this process chiefly inorganic impurities, parts of insects and woody fibre are removed. They remain in the bag, are collected and form the so-called refuse shellac. The composition of this refuse showed that it is still quite valuable. It arrives here in cakes of a reddish brown color.

According to my investigation, it contains still about 70% of alcohol soluble matter, and about 1% of resinous material, removable only by carbonate of soda treatment. The 29% remaining consists mainly of organized debris of insects and plants. They yield 4.8% ashes, mostly lime, soluble in acid, and 24.2% organic matter, also to a considerable extent soluble in H Cl.

From this it is evident that Seedlac, which contains still the refuse lac, yields more matter soluble in acid, but also more resinous oil. So, for instance, there was found in

	Non-condensible Resinous Oil.	Water and Acid Soluble.
Teelhar Seedlac	10.55	5.80
" "	10.63	——
Koosmi Seedlac made from Sticklac in laboratory	9.64	4.35
" "	9.24	——

If rosin is added to the Seedlac, when adulteration is aimed at, then the refuse lac, of course, also contains pine rosin.

The proper way to analyze refuse lac is simply to determine the alcohol soluble portion and treat this with sand and hydrochloric acid in the manner prescribed for shellac, taking heed of the absence of the wax in the alcoholic extract. Pressed out pure shellac contains but little of these impurities, generally only about 15% of the non-condensable substances.

D. C. shellac contains, according to my examination:

	Total	Organic Oils and Resins	Salts
	7.48	6.48	1.00
Prepared from D.C. sticklack in laboratory	7.22		

My figure allowing 8% is based upon these examinations, and gives to the manufacturer a leeway of a fraction of one per cent., which I now consider ample. I examined a series of V S O samples of shellac, partly reported to be free from rosin, partly believed to be so, for non-condensable resins and oils.

By my method the following figures were obtained:

Year of Delivery	Non-condensible Resinous Portion
1903	9.98
1904	9.24
1905	8.55
1906	8.30
1907	12.64

from which it is evident that they contained colophony in quantity from 3-6%. My qualitative test showed the rosin plainly in all of them. In order to ascertain the nature of the oily acids I have dehydrated the shellac by heat only, then extracted the foreign alcohol soluble matter by alcohol. The residual shellac is then hydrated again by means of soda.

This part of my work will consume some time but will be reported later.

New York, Dec. 9th, 1907.

DIAMONDS IN PLACE IN THE UNITED STATES.

Although diamonds have been found in at least thirty places in the United States, the only locality where they occur in place has recently been discovered and has been investigated by Mr. George F. Kunz, the gem expert, and Dr. H. S. Washington, petrographer. They occur in an igneous rock, similar to that of the South African mines, which forms a small stock near Murfreesboro, Pike County, Ark. The first two stones were found August 1, 1906, and since then many of them have been picked up, the total number found at last report being 130. Many of them are white and of good water others are yellow, and some are of brown bort. The two largest stones weigh 6½ carats, one being exceedingly fine white and the other brown. They are found on the surface as well as within the greenish, friable, decomposed peridotite, a rock somewhat like the famous "blue ground" of Kimberly. The property is being actively prospected and developed.

BROWN IRON ORES OF ALABAMA.

As a producer of brown ores Alabama ranks first among the iron-producing States. In 1905 there were 781,961 long tons of brown ore mined in Alabama, and over 36 per cent. of this was produced in the Russellville district. This district situated in Franklin County, in the northwestern part of the State, comprises an area of about twenty-five square miles, within a rectangle eight miles from east to west by about three miles from north to south, with Russellville near the middle of the northern edge. The Northern Alabama Railroad crosses the area from north to south, connecting the ore mines and limestone quarries near Russellville with the blast furnaces near Sheffield. It is a matter of historical interest that probably the first furnace erected in Alabama was built in this district in 1818, on the north bank of Cedar Creek, where surface ore fed to a primitive charcoal furnace was made into cast and malleable iron. The furnace was probably abandoned about 1827. Sixty years later iron-making was revived in this region, but in a better location in respect to water supply and transportation routes.

The iron ores of the Russellville district occur in irregular masses, bowlders, pebbles and sand, and as cementing material in beds of conglomerate. They are dark brown in color and have generally been termed limonite. These ores are the subject of a brief paper prepared by Mr. Ernest F. Burchard, of the United States Geological Survey, and published by that bureau in Bulletin No. 315 (Contributions to Economic Geology, 1906). That this report is particularly timely is shown by the fact that, although considerable areas of proved lands still await development in the Russellville district, land owners and persons concerned in the iron trade display an ever-increasing interest in the possible distribution of brown ores in other parts of the region. As similar geologic conditions exist throughout the northern part of Franklin County and the southern and western parts of Colbert County, Alabama, the eastern part of Tishomingo County, Mississippi, and parts of the Tennessee Valley in Tennessee and Kentucky, deposits of brown ore resembling those of Russellville may be discovered in the localities mentioned. Attention is called to the fact that as surface prospects are not invariable indication of the extent or value of the ore beds below, there may be local segregations of ore many acres in extent that do not appear at all at the surface. It is suggested that information of such occurrences may be obtained by small test wells, three or four feet in diameter and twenty to fifty feet deep, which may easily be sunk in the loose loam and gravel. The main fact to be borne in mind is that localities worth prospecting for brown ores are underlain by limestone beds which are surfaced with 20 to 100 feet of loam and gravel.

Bulletin No. 315 may be obtained by applying to the Director of the United States Geological Survey, Washington, D. C.

Section of Photography and Microscopy.

(Stated meeting held Thursday, January 30th, 1908.)

Teachings and Practice of the Lumiere Starch Grain Process.

BY J. E. BRULATOUR.

THE PRINCIPLE OF THE PROCESS.

If on the surface of a sheet of glass, and in the form of a single film, a collection of microscopic elements, transparent, and colored reddish orange, green, and violet are spread, we shall find, if the spectral absorption of these elements is correct, and if they are *in correct* proportions, that the film thus obtained, when examined by transmitted light, will not appear colored; this film will only absorb a fraction of the transmitted light.

The luminous rays traversing the fundamental screens, orange, green, and violet, are reconstructed, and from white light if the sum of their surfaces for each color, and the intensity of the coloration of the constituent elements exist in proper proportions. The thin trichromatic film thus formed is subsequently coated with a panchromatic emulsion.

If now such a plate be submitted to the action of a colored image, taking the precaution to expose it through the back, the light rays traversing the fundamental screens, will, according to their color and the color of the screens they encounter, suffer a variable absorption. Thus we realize a selection by the microscopic elements which enables us, after development and fixation, to obtain colored images; the colors being complementary to those of the original.

HOW THE COMPLEMENTARY (NEGATIVE) IMAGE IS FORMED.

If we take, for example, a part of the image colored red, the red rays will be absorbed by the green elements of the film, whilst the violet and orange elements will transmit them. The panchromatic film, therefore, will be acted upon under the orange and violet elements, and the green elements will appear, after the fixation, because the panchromatic film has not been acted upon under the green elements.

Development will reduce the silver bromide of the films and

mask the orange and violet elements, and the green elements will appear, because the silver bromide has not been reduced under them. We have, then, in this case, a residue colored green, which is complementary to the red rays we have been considering. The same phenomena will occur with the other color; that is to say, with green light, green elements will be masked, and the film appear red. In the case of yellow, the violet image will appear, and so on. It will be seen that a negative in these complementary colors ought to give, with a plate prepared in the same way, positives which would be complementary to the negative; that is to say, positives which would produce the colors of the original.

One might also, after development of the negative image, omit the fixation, and reverse the image by one of the well-known methods so as to obtain a positive direct, which would present all of the colors of the original object.

The difficulties which we have encountered in the application of this method are numerous and considerable; but, after laborious researches we have surmounted them, and the Lumiere Company is prepared to supply such plates.

It will be sufficient to briefly indicate some of the most important conditions which had to be fulfilled to prove how delicate the problem was.

TECHNICAL PROBLEMS OF THE PROCESS.

We have first to find the film formed of microscopic filters, orange, green, and violet. It was necessary that this film should adhere to its support, be very thin, and that the coloration of the elements of which it would be composed should be rigidly determined as regards intensity and exactness of color, and as regards the number of elements to a given area. The colors must be stable, they must not run, and there must be no superposition of the colored filters, and no interspaces. Finally, the film has to be covered with varnish having the same index of refraction as the grains.

It was essential that the sensitive film should be orthochromatized—so that there should be no false rendering of colors—and that this orthochromatizm should be in a relation to the nature of the emulsion and the color of the elementary filters. The film of the emulsion should be of a special nature to prevent

diffusion, and the manipulations, development and exposure should be appropriate to these preparations.

The simple enumeration of one of the conditions will serve to show how much care and method is necessary. First, potato starch had to be separated by instruments specially devised for the work, for the grains have a diameter of from 15 to 20 thousandths of a millimetre. These grains were divided into three lots, which were respectively stained reddish-orange, green, and violet, by the aid of special coloring matters.

The colored powders thus obtained were mixed, after complete desiccation, in such proportions that the mixture did not show any residual color. The resultant powder was then brushed on to a sheet of glass, covered with a sticky substratum. With suitable precautions, we shall obtain a single film of grains, which touch each other without any superposition.

The interspaces had to be filled by a similar process of powdering so that no white light was transmitted. This obscuration is effected by means of an extremely fine, black powder of wood charcoal, for example.

We have thus formed a screen on every square millimetre of surface, of which there are eight to nine thousand of small elementary screens, orange, green, and violet. The surface thus prepared is protected by a varnish having about the same refractive index as that of the starch grains, a varnish as impermeable as possible, on which finally a thin film of sensitive panchromatic emulsion of silver bromide is coated.

The exposure is made in the ordinary way in any camera, but in every case taking the precaution to reverse the plate so that the rays from the lens traverse first the colored particles before reaching the sensitive film. It is also necessary to interpose a special yellow screen to compensate for the excessive activity of the violet and blue rays. The absorption due to the interposition of the colored elements, although a very sensitive emulsion is used, necessitates a somewhat longer exposure than usual. Still, it is possible to obtain results in sunshine in one-fifth of a second, with a lens working at f/3.

Development is effected as in an ordinary photograph, and if one is content to fix the image, the result will be, as we have already pointed out, a negative presenting by transmitted light the colors complementary to those of the object photographed. But

it is preferable to re-establish the order of the colors, on the same plate, by chemical reversal of the image. For this, the silver reduced by the developer is dissolved by a suitable bath, and then the remaining silver bromide is developed, producing a black image, which is complementary to the negative obtained by the first development.

It will thus be seen that the manipulations are simple and only slightly different from those of ordinary photography.

PETROLEUM IN ITALY.

As early as 1893 a French company obtained a concession from the Italian Government to explore a certain tract in the Apennines, near Piacenza, and to export any deposits of petroleum found there. The success of this company was sufficient to cause the formation of another French syndicate four years ago, and last July these two were absorbed by a Genoese company, with a capital of $3,000,000. The wells already bored are some 95 in number, of which 70 are practically exhausted. The remaining 25 produced about 40,000 barrels of crude oil in 1905, and with the eight wells now boring it is expected that the total production for 1906 will have reached over 65,000 barrels. The concession of the new company comprises about 11,000 acres.

The wells, none of which are gushers, reach a minimum depth of 1300 feet and the engineers in charge say that those which are exhausted may be made to yield again by deepening. This has not as yet been undertaken, perhaps because by the terms of the grant it is necessary to bore new wells in order to maintain control of the territory. A central motor is used to operate, by cables, the pumps of the various wells.—*Eng. and Min. Jour.*

Old age pensions for workingmen will be made the chief object of the labor members of the British Parliament at the present session. The Parliamentary Committee of the Trades Union Congress, in its public manifesto urging this legislation, says that commissions and committees have sat long enough and that the time has come for action. It states that "half a million of old people over sixty-five years of age are dependent upon charity or Bumbledom for the ordinary necessaries of life; the pressure of workshop life is such that old people find increasing difficulty in getting employment, and the workhouse is, in too many instances, the only refuge after a life of labor." It is added that about 200,000 persons are now in receipt of over £9,000,000 a year in pensions from the exchequer, most of whom were well paid in the public service. The plea is that the "soldier of labor" be now put on the list.—*Iron Age.*

Mining and Metallurgical Section.

Recent Advances in the Metallurgy of Zinc.

BY WOOLSEY McA. JOHNSON.

For a proper and precise understanding of the changes and improvements in the treatment of zinc-bearing ores, attention must be given to the peculiarities of the reduction of zinc oxide to the metal.

The temperature at which zinc oxide begins to be reduced by carbon varies with the physical nature of both oxide and carbon but has been shown to lie between 1020°C. and 1100°C.* The boiling point of zinc at atmospheric pressure is 920°C. Consequently we have zinc vapor formed when zinc oxide is reduced.

The further fact that zinc vapor is oxidized with avidity with weak oxidizers as water-vapor and carbon dioxide necessitates the use of a large excess of fixed carbon, so that the gas of reduction is practically speaking carbon monoxide.

We therefore see that indirect heating of the roasted ore and coal is a *sine qua non* in the reduction of zinc ores.

Also it can be stated that this zinc vapor is condensed into metal under conditions but imperfectly understood by the average zinc metallurgist and always in small condensers.

Finally, from these theoretical conditions we have the resulting practical conditions that zinc ores are roasted to a dead roast, mixed with fine non-caking carbonaceous material and charged into small fire-clay retorts, holding from 50 to 80 pounds

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*Woolsey McA. Johnson, "Thermo-Electric Determinations of the Reduction Temperature of Zinc Oxide." Trans. American Electrochemical Society, April, 1904.

of ore, heated by a gas flame, the volatile products passing into condensers where the metallic vapor is condensed.

The commercial conditions are that from $2\frac{1}{4}$ to $3\frac{1}{2}$ "men-days" and from $2\frac{1}{2}$ to $3\frac{1}{2}$ tons of coal, or its equivalent in natural gas, are needed to treat one ton of zinc concentrates at the reduction plant; that the cost of treatment in America is usually from $10.00 to $14.00 per ton of ore (running as high as $17.00 in one plant); that 140 lbs. to 170 lbs. of zinc per ton of concentrates are lost in treatment.

Naturally, the tendency is to locate plants at points in coal fields or in natural gas fields. As the fuel needed is in excess of the ore, the ore is always brought to the fuel field.

In the United States, the peculiarities favoring the development of the zinc business almost seem to have been given by Providence. Let us take the great mining district called the "Joplin field" and the Missouri and Kansas smelting plants. In the first place the ores at Joplin require only simple water-concentration in order to produce a concentrate averaging over 58% zinc. The mines are near the surface and require the simplest facilities. Only a few miles distant from this field are coal fields which produce a large tonnage of slack suitable for use in the Belgian type of zinc furnace.

Hence, this development did not need great amounts of capital. Furthermore, the treatment of the pure concentrates was easy provided the condensers were enlarged because no fluxing mineral impurities were present to prevent hard firing. A supply of native labor was at hand which in a decade became expert at the furnace labor. Finally, a set of resourceful entrepreneurs, who though not metallurgists were hard-headed business men, took up the zinc business. In addition, the clay of the clay beds near St. Louis are extremely suitable for retort making.

We thus find that from 1880 to 1896, the business of the Missouri-Kansas zinc miners and smelters grew fast and flourished with our country's industrial growth.

In 1898, labor became scarce and dear, and by great fortune, at about the same time the "Iola" gas field was found and the "Iola" type of natural-gas fired zinc furnace was devised by hard work in the zinc fraternity, where the work of the furnace was so systematized that the labor-charge was diminished. And over

60% of the spelter is to-day made in the "Kansas-Indian Territory" zinc smelters, using gas as fuel.

Further analysis would show the reasons for existence of the zinc smelters in Illinois, with their by-product acid plant, and the zinc plants in the anthracite field drawing their ore from the great Franklin mine of the New Jersey Zinc Company. But this short sketch of the business is to impress the fact that the conditions for zinc smelting are unique, because of the large amount of fuel used and the high labor-charge per ton of ore, and the required absence of fluxing impurities in the ore.

Consequently, zinc ores are mined and concentrated so as to ship to the American smelter plant a product that when roasted will analyze at least 38% zinc. The Joplin ores "roast" to 70% zinc. Previous to 1903, little ore was used in the Western spelter plants that averaged under 65% zinc roasted.

The progress in the treatment of zinc ores has been in two directions, the bettering of the concentration methods producing from complex sulfides a higher grade concentrate, and in the treatment of the "ore" in the spelter plant.

It is peculiar that the art of concentration of complex zinc ores has improved so as to make a concentrate higher in zinc and that the art of reducing zinc "ores" to spelter has improved so that a "concentrate" or "ore" lower in zinc could be treated in the retort. This metallurgical compromise has had the effect of increasing the spelter production from ores other than Joplin. Whereas five years ago the Western zinc smelters treated only Joplin concentrates, to-day the tonnage of ore from Mexico, Colorado, New Mexico and Wisconsin sent to the Illinois and Kansas smelting centers approximate the production of the Joplin field.

Joplin, however, is still prëeminent in its influence on the metal markets for the reason that over 60% of the metal produced in the United States comes from ore hoisted from shafts in the prairies of Jasper County.

Joplin concentrates make nearly double the tonnage that "Western" or Mexican stuff does, and as a company's hold on the metal markets depends on tonnage, in times of great demand for metal it is better to run on Joplin ore. In times, when the "margin" for the spelter plant is small, as just now, (in other words, when metal is sold at "auction-room" prices), the margin on low-grade "Western" ores is larger and capital invested in ore stocks

smaller, and difficulty of selling restricted tonnage of metal is lessened. These are the main commercial principles governing the treatment of low-grade concentrates.

The advance in the treatment of zinc ores of the Rocky Mountains by "ore-dressing" has been due to the pressure on the "West" for ore, due to the fact that Joplin could not increase its production apace with the enormous demand for ore.

In my opinion, the chief reason for the improvement, the germ as we might call it, was the "Blake-Morscher" electro-static machine. I am aware that this machine is not the great practical success that was predicted, but still it stimulated work in the treatment of complex ores of the "West."

Parenthetically it may be remarked that in the zinc business the "West," as a term. applies to the country of the "Rockies," as distinguished from the Joplin field.

The Blake-Morscher machine depends on the fact that metallic sulfides with a metallic lustre conduct electricity, while zinc sulfide and the gangue minerals, as quartz, barytes, calcite, etc., do not. Accordingly when a mineral product containing iron pyrites and blende is dropped on a charged roller the iron pyrites assume the same charge as the roller and is repelled (sometimes thrown with violence five or six feet), while zinc blende slides down in so short a time that it is not repelled. Consequently a separation is made between the zinc sulfide and iron sulfides of the "zinc-iron middlings" of the "Wilfley" table. Profs. Blake and Morscher, of the University of Kansas, made the first practical application of this, while Mr. W. G. Swart, of Denver, by hard work, has helped in evolving the machine to commercial success. A complete account of it is given in the Report of Mr. W. R. Ingalls, relative to the zinc resources of British Columbia to the Dominion Government, pages 118-121.

The Blake machine has not been much of a success as yet in other than dry climates. For instance, it succeeded in the mill of the Colorado Zinc Company, at Denver. But as yet has made no large success elsewhere.

The Sutton-Steel[2]-Sutton machine has been developed in El Paso, Texas. It works on the same general principles as the Blake. But as yet has made no demonstrated practical success. As it is developed in a mining center, it has the benefit of direct practical contact with the needs of the mines.

The so-called "Huff-Dolbear" machine has been developed in Boston. It has had the benefit of the advice of such authorities as Prof. R. H. Richards in the "ore-dressing" line, and Prof. Elihu Thompson, of the General Electric Company, in the electrical end of it. Seven years ago, when I was a student at Harvard, I saw one of their experimental machines. Just lately, a strong zinc mining and smelting company have taken hold of the commercial exploitation of the machine. So long is the period of gestation of a radically new process.

The great trouble with these electrostatic machines is the lack of proper knowledge of the scientific conditions of the problem. This is to be expected, as electrostatics is a part of electrical science that has not had much practical application. In the future, as a better understanding of the question is attained, a greater degree of success can be reached. My practical friends may laugh, but my opinion is that hard and close study of the philosophy of the subject is a *sine qua non* for success.

Of far great actual importance, in the way of financial returns, is the Wetherill magnetic separator. This has had its great success at the works of the New Jersey Zinc Company at Franklin Furnace, N. J. The ore of the Franklin mine analyzes roughly 20% zinc. The zinc is present chiefly as willemite, the anhydrous silicate of zinc and the magnetic franklinite, a complex of iron oxide, manganese oxide, and zinc oxide. The ore is subjected first to a preliminary water concentration to remove the gangue. The heads, containing willemite and franklinite, are dried and passed over the belts of the Wetherill machines. Here magnets of high intensity lift up the magnetic franklinite and leave the non-magnetic willemite. The "willemite-product" analyzing 47% zinc is sent to the spelter plant and the franklinite analyzing 22-26% zinc is mixed with coal and "blown-up" to zinc oxide in the "oxide" furnaces, which is later caught in a "bag-house" and sold as a most excellent pigment—"zinc white." The residue or clinker from this operation is smelted in short iron blast furnaces to produce iron-manganese, or "spiegel-eisen." The "spiegel-oxide" caught in hot blast stoves and flues of the blast furnace and the "refuse-oxide" from the flues of the oxide plant is a most excellent material to charge into the spelter retort. Due to the fact that the grade of the ore is so high (four or five times that of the Joplin field), and to the fact that the price of products is high by

reason of their unequalled purity, the operation is most profitable. Because of the neatness of the chain of related metallurgical operations, the recovery of metalliferous products from the ore is the highest of any zinc company in the world.

In the "West," the Wetherill machine has had a peculiar use. Zinc blende contains usually varying percentages of combined iron. As this percentage increases, the product becomes slightly magnetic.

The so-called "marmatite," or zinc-iron mono-sulfide, contains some 10% "combined iron." The large dumps of "middlings" of the lead mills of Colorado were composed partly of "marmatite." These were dried and passed over Wetherills and a product analyzing from 42% to 46% zinc produced. By 1903, certain of managers of the zinc plants learned how to treat such a product. The Colorado Zinc Company treats these ores and middlings by a complicated process. The stuff as it came to the mill was tabled and three products made: (1) a lead product for the lead plant; (2) silicous tailings; (3) zinc iron middlings. (2) was usually thrown away, (3) was dried and passed over Wetherill machines. In this operation, the magnetic zinc-iron sulfide was separated and sold to a spelter plant. The non-magnetic portion was passed over the "Blake" electrostatic machines. Here, two products were made, the non-conducting zinc product and the iron-product, containing a little lead. This was sold to a lead smelter for a flux. Although the recovery of the zinc was not high, yet the process attained a degree of commercial success.

Lately, the future of the zinc business in the "West" has been brightened greatly, to my mind, by the advent of the Wilfley "roaster." This is the result of ten years' experimenting by that most brilliant yet practical inventor, Mr. W. R. Wilfley.

The first work was done at his "Pride of the West" mine, Washington, Arizona.

It is easy in a hard glass tube to heat iron-pyrites to a low heat and make it magnetic. It is hard to do this on a large scale efficiently and cheaply, because the operation is very delicate. The Wilfley roaster is a high fire-brick shaft with an auxiliary fire-box. The gases from the fire-box flow *down* with the shower of ore. The iron "sulfides" are changed instanter to a magnetic product, consisting of a shell of magnetic oxy-sulfide round each kernel of unroasted material. The ore strikes a water-cooled

shaking hopper, and at once further action is stopped. If the hot gases come upward, the ore would be over-roasted. The Wilfley roaster puts through an enormous tonnage at a low cost. Also, its capital cost per ton of ore is small.

The Wisconsin field has developed a similar operation in a revolving cylindrical roaster. Mr. John E. Dwight also attained similar results at Warren, N. H., some five years ago.

The machine used to separate the magnetic iron material is preferably a low intensity machine, like the "Cleveland-Knowles" or the "Dings." For a detailed description of these the reader is referred to Ingall's above-mentioned report, pages 102-107.

This operation is going to have a great use throughout the zinc mines of the world.

The next important relative advance step in the art of zinc metallurgy is the so-called "flotation" process. The physical chemistry of the operation is but little understood. The practical facts are that when zinc material containing blende is stirred in a hot chemical solution, bubbles are formed. These attach themselves to the zinc blende and rise to the surface, forming a scum which is often a thick curd. This is floated off, the solution allowed to cool and the particles of blende fall down in the cooled solution, in the way grounds of coffee drop when coffee is cooled.

The process seems to have first been invented by Elmore, who mixes crude oil with his ore previous to treatment. Elmore also uses a vacuum to lift the particles of ore.

Some six years or so ago, the "flotation" process was developed more or less independently of Elmore's idea by Messrs. Potter, Deprat and Carmichael severally and conjointly. It would seem from what I can learn that Potter was the real inventor of the practical "flotation," though of course the germ-idea of "flotation" is contained in the original Elmore oil-acid vacuum patent.

It is proven definitely that the gas is carbon dioxide derived from the carbonates in the ore.

Mr. de Bavay even charges the ore with carbon dioxide which can be derived from the gases of combustion of coal, *e. g.*, from the chimney of the boiler plant.

Most of the particular work on the "flotation" process has been done at the Broken Hill mines in Australia.

Mr. W. M. Sanders, when working for me in the laboratory for

metallurgical research of the Lanyon Zinc Company, built at the direction of Mr. F. E. Drake, found that an alkaline aluminum sulfate bath was an efficient "floating" solution. He is now building several plants in the Southern Illinois-Kentucky field to separate blende from fluor-spar. It is impossible to treat in the retort ores containing over 1.5% or 2% fluor-spar, as fluor-spar attacks with avidity the fire-clay of the retorts. And as the two minerals have specific gravities nearly the same, they follow each other closely in water-concentration.

Sanders makes a high-grade product at a high saving, and his work from a metallurgical standpoint is ahead of any figures that I have received relative to the other processes. He also effects a separation of minerals other than fluor-spar from blende.

Mr. H. S. Clark and Mr. Hayman Claudet have been energetically pushing the Elmore oil-acid-vacuum process in this country.

I look for these "flotation" processes to have great influence on the art of treating "complex" sulfides. Their great attraction to me is the fact that they have a great capacity in tons per day for capital outlay. This is the desideratum in any new process.

IMPROVEMENT IN WATER-CONCENTRATION.

This, in a way, should have been treated first. But the more radical new electrical methods have been the stimulation to this improvement, and so came first in the more logical way.

Simplest of all is "sorting" of the ore in the mine and on the picking belt. With the personal equation working at its highest efficiency, "sorting" is a neat and effective way of increasing the saving and the tonnage of a plant. But with slack superintendence, a poor psychology infecting the force, it is most wasteful.

Next, comes careful graduated crushing, reducing the ores by steps so that the constituent minerals are separated from each other without the production of a large percentage of "slimes."

Thirdly, I would place improvement in screening. There have been invented in the past five years several new screens working wet or dry, which, when installed in a thoroughly workmanlike manner, do efficient work. These also reduce the percentage of slimes and make a sized product for the concentration plant.

Fourthly, it is found that such simple expedients as, for example, larger pulleys and shafts for the shaking tables, solid concrete foundations for the same, as well as an even feed of ore and water, increases marvellously the efficiency of the old-fashioned mill of Joplin and the West.

All these several factors change the balance between success and failure. Often they do away with the necessity of the newer forms of concentration except in ores very "crypto-crystallic" in their nature.

There are several more possibilities in the ore-dressing of complex sulfides, such as the McQuestin "tubes," direct concentration, and the "dry-jig," but these, to my mind, have not had the direct practical bearing on the problem that some of the others have had.

Improvement has been made in so many different ways that to-day there are few zinc mines whose ores cannot be treated at a profit, provided that a rational use of known and tried methods and providing the mine is not too far distant from the smelting centers, and the ore is not too low-grade.

All these improvements in ore-dressing would have had little or no effect in the United States outside of the "Joplin" field, and possibly the "Wisconsin" field, had not the spelter plants unbent from their rigid attitudes towards zinc concentrates higher that 1% in iron.

IMPROVEMENTS IN THE REDUCTION PLANTS.

Let it be stated that American practice of reducing zinc ores is radically different from the European practice, for the three following reasons:

(1) Labor in America is dear.

(2) Coal in America is cheap.

(3) Joplin concentrates were abundant from 1880 to 1900, and averaged over 68% zinc roasted.

In Europe labor is cheap, and the calling of the zinc smelterman has been followed for two or three generations in the same family. The ores on which the European smelter plants have depended for supplies, do not average much over 48% zinc roasted.

In America, we use a charge that gives a residue, intended to be

without slag. In Europe, the residues are often sticky, because it is economical with their conditions to scrape them out.

In America, they are usually "blown out" by the auto-generated steam from a pipe, through the perforated end of which jets water.

It would take up too much space to expatiate on all the practical and commercial facts that have resulted in America from these differences. The reader is referred to my paper read before the American Institute of Mining Engineers of Toronto, July, 1907, for a more detailed description.

In treating iron-bearing ores from Leadville, Col., and elsewhere, American practice has simply been a continuation of the practice on Joplin ores and the use of extreme care to make a "dry" or non-corrosive charge. In the first place the charge is "cut" or reduced about 8% to 10%. Next a higher grade fuel is used and a larger percentage of this because the pounds of ore per cubic foot of retort space has been lessened.

We thus have "the pounds of fixed carbon per cubic foot or retort-space" increased and "the pounds of fusible matter per cubic foot of retort-space" decreased. Due to the increase in the ratio or reducing material to "ore," the reductivity of the charge is greatly increased.

Consequently, the zinc is reduced at a lower temperature. Measurements I have made show a temperature some 200° C. less than in Joplin ore.

In addition, exceeding care must be used to reduce the sulfur in the roasting operation to a minimum in ferruginous ore. For, it is pretty well known that iron-sulfide is the corroder of retorts.

Some of my own experience illustrates this. Having seen the necessity in the reducing agent for high fixed carbon and a maximum of carbon activity, I had long been trying to get a material with those two properties as well as very little ash. I tried charcoal and ran a furnace of 330 retorts on a "mix" with varying proportions of charcoal. But charcoal is too bulky and expensive.

Finally, we hit on "oil-coke," analyzing 1% ash, 3% or 4% volatile matter and 94% or 96% fixed carbon. This we found contained heavy hydrocarbons which distilled and condensed in the condenser. Thereby the condenser was choked up.

I therefore rigged up one of our bee-hive coke ovens with a large fan-tail burner and connected this to one of our natural gas

mains. I used this gas so artificially introduced to finish the coking action, just as if it were coal, and in coke furnished its own gas by distillation. We thus made a material practically pure carbon. The cost was not excessive and it would have been possible to increase the furnace charge in ore so much as to be very profitable because of increased metal tonnage we could make with the cheap fuel.

Having worked up five or six tons of this oil-coke to this form, (we slangily called it "boiled coke"), I gave instructions to have it crushed in one of the ore mills, and said particularly that the elevator boots and all must be well cleaned out. I then went to one of the other plants of the company six miles away. On my return, I had three small charges mixed up with 5%, 10% and 15% respectively increased ore charge, to test out our new and ideal reducer.

The "flame" was strong and our residues low in zinc, less than 3%. But the charge "stuck" to the retort most peculiarly. We were puzzled but still kept on. The third charge left the retorts leaking iron sulfide, or rather the iron oxy-sulfide silicate, which results from iron sulfide reacting on fire-clay, through every microscopical crack which it had found out.

The mystery was still unsolved, until I thought of the fact that recently a tonnage of very pyritic ore had been crushed in the same crushing plant that we had used for our "boiled-coke." I then had a sample taken of the coke and found that it analyzed some 7% sulfur. The raw pyrites had done the business and ruined the retorts in three days. This shows exactly what iron sulfide will do in the retort.

One of the great reasons for improvement in the treatment of the so-called low-grade zinc ores from the "West" was due to more careful roasting in the Cappeau-Ropp and Zellweger machine roasters.

Improvement in the mix, so as to give a non-corrosive residue and a charge that would "give up" its zinc at a temperature less than 1175°C. was, as we have shown, another cause.

Great care in the manipulation of the flame outside the retort in the zinc furnace was a third.

Gradually, the zinc smelters of the West are improving the practice, though I doubt if any of them are surpassing much the record of the No. 2 works of the Lanyon Zinc Co. when I was met-

allurgist of that concern, some three years ago. Then we ran with an average charge per furnace for the entire plant of 11900 lbs. of roasted ore, analyzing less than 44% Zu and 19% Fe on a furnace loss of about 19% for the entire month with poor coal and other adverse conditions.

In conclusion let me state that I have not mentioned any of the so-called "wet" zinc processes, because they have achieved no practical and commercial results, nor with the tremendous capital cost needed are they, in my opinion, to achieve any. Parenthetically let it be said that quantitative analytical methods writ large do not spell metallurgy. Nor do reactions suited for a gram of stuff, work well on hundreds of tons.

Nor have I spoken of the Lungwitz "pressure-furnace;" for in spite of great outlay in development, it has had no success on a large scale. I have not given any attention to the electric furnace on which I have been working for nearly five years, for that though promising has not yet been proven for anything commercially but refining dross, etc., and making a high-priced metal.

Undoubtedly, we will see in the next ten years a revolution either in a moderate way by the use of larger inclined gas-fired continuous retorts or in the direct electric furnace. But of one thing I am certain, and that is that the only way to effect any improvement in metallurgy of zinc or any other metal is by a most accurate metallurgical study of the reactions on a small scale with the pyrometer and a most skilful and illuminating forecast of the commercial working of these reactions on a large scale, with regards to labor-saving, metallurgical geography and metallurgical economics; of combining the known with the unknown in a most common-sense way.

That there is an abundant chance for this in the treatment of zinc ores, is seen by the fact that the leading smelters of the country waste annually about as much zinc as is consumed as spelter in the mechanic arts in the United States.

The fact that there are at least six powerful companies in the zinc business will engender a strong competition, for where there is a large field and no favorites, the prize goes to the swiftest and strongest.

Book Notices.

PUBLICATIONS RECEIVED.

United States Commissioner of Education. Report for the year ending June 30, 1906. Volume I, 643 pages, 8vo. Washington, Government Printing Office, 1907.

Michigan State Board of Health. Thirty-fourth annual report of the Secretary for the fiscal year ending June 30, 1906. 176 pages, 8vo. Lansing, State Printer, 1907.

Syracuse Chamber of Commerce. Report upon Smoke Abatement. An impartial investigation of the ways and means of abating smoke; results attained in other cities; merits of patented devices, together with practical suggestions to the Department of Smoke Abatement; the steam plant owner and the private citizen. 42 pages, 8vo.

Canadian Mining Journal, publisher. The Ontario meeting of American Institute of Mining Engineers and their tour through the districts of Cobalt, Sudbury and Moose Mountain. 89 pages, illustrations, portraits, plates, maps; 8vo. Toronto, Canadian Mining Journal, n. d.

Rijckevorsel, Dr. van. Konstant auftretende Secundäre Maxima und Minima in dem jährlichen verlauf der meteoroligschen Erscheinungen. Four parts; illustrations, tables, quarto. Rotterdam, W. J. Van Hengel, 1905 to 1907.

Earthquakes. Supplementary to a booklet entitled, "From Rime to Reason; or, Great San Francisco Earthquake Rhythmically, Orchestrically and Logically Considered." 14 pages, 8vo. Columbus, Ohio, Clarence Miller Jones, 1907.

Science and Art. 6 pages, 8vo. Columbus, Ohio, Clarence Miller Jones, 1907.

New York Merchants' Association. Pollution of New York Harbor as a menace to health by the dissemination of intestinal disease through the agency of the common house fly. A report by Daniel D. Jackson, S.B., to the Committee on Pollution. 22 pages, illustrations, plates, quarto. New York, Merchants' Association, 1907.

United States Bureau of Steam Engineering. Annual report of the Chief to the Secretary of the Navy for the fiscal year 1907. 56 pages, 8vo. Washington, Government Printing Office, 1907.

Pennsylvania State College Agricultural Experiment Station. Bulletin No. 84. Feed as a Source of Energy. 16 pages, 8vo. State College, 1907.

U. S. Department of Agriculture, Forest Service, Gifford Pinchot, Forester. The use of national forests. 42 pages, illustrations, 12mo. Washington, Government Printing Office, 1907.

Pennsylvania State College Bulletin, Vol I, No. 8, October, 1907. Winter Courses in Agriculture at the Pennsylvania State College. 16 pages, illustrations, 8vo. State College, 1907.

On the Concentric Method of Teaching Electrical Engineering by V. Karapetoff. 16 pages, illustrations, 8vo. New York, American Institute of Electrical Engineers, 1907.

The Human Side of the Engineering Profession, by V. Karapetoff. Abstract of an address, delivered before the New York Electrical Society, Edison Auditorium, October 31st, 1906. 6 pages, 8vo. Ithaca, N. Y., 1906.

U. S. Department of Agriculture, Forest Service, Circular 115. Second progress report on the Strength of Structural Timber, by W. Kendrick Hatt. 39 pages, 8vo. Washington, Government Printer, 1907.

Pennsylvania State Highway Department. Report for the year 1906. 21 pages, illustrations, 8vo. Harrisburg, State Printer, 1907.

Zoological Bulletin of the Division of Zoology of the Pennsylvania Department of Agriculture. Subject: The San Jose Scale. Vol. 5, No. 6. October, 1907. 30 pages, illustrations, 8vo. Harrisburg, State Printer, 1907.

United States Geological Survey. Mineral Products of the United States, Calendar Year 1897 to 1906. Sheet 24 x 32 inches. Washington, Government Printing Office, 1907.

U. S. Department of Agriculture, Forest Service. Circular 114. Wood Distillation, by W. C. Geer. 8 pages, 8vo. Washington, Government Printing Office, 1907. Circular 116. The Waning Hardwood Supply and the Appalachian Forests, by William L. Hall. 16 pages, 8vo. Washington, Government Printing Office, 1907. Circular 122. The Lumber Cut of the United States, 1906. 42 pages, table, 8vo. Washington, Government Printing Office, 1907.

Königliches Materialprüfungsamt der Technischen Hochschule Berlin. Bericht über die Tätigkeit des Amtes im Betriebsjahre, 1906. 75 pages, quarto. Sonderabdruck aus den Mitteilungen aus dem Königlichen Materialprüfungsamt Gross-Lichterfelde West, 1907.

U. S. Department of Agriculture, Forest Service, Circular 134. The Estimation of Moisture in Creosote Wood, by Arthur L. Dean. 7 pages, illustrations, 8vo. Washington, Government Printing Office, 1908.

U. S. Department of Agriculture, Forest Service. Circular 132. The Seasoning and Preservative Treatment of Hemlock and Tamarock Cross-ties, by W. F. Sherfesee. 31 pages, illustrations, 8vo. Washington, Government Printing Office, 1908.

U. S. Department of Agriculture, Forest Service. Circular 133. Production of Veneer in 1906. 6 pages, 8vo. Washington, Government Printing Office, 1908.

Ontario Bureau of Mines. Sixteenth annual report, 1907 (Vol. 16, Part I.) 248 pages, illustrations, maps, 8vo. Toronto, King's Printer, 1907.

Souvenirs Entomologiques par J. H. Fabre. Dixieme Serie. Etudes sur l'Instinct et les Mœurs des Insectes. 353 pages, illustrations, 8vo. Paris, Ch. Delagrave, n. d. Price, in paper, 3 francs, 50c.

In the present volume the author continues his interesting studies on the instincts and habits of insects. He has collected much material on the subject and is able to place it before the reader in an entertaining way.

A. R.

Die Elektrochemische und Elektrometallurgische Industrie Grossbritanniens von John B. C. Kershaw. Ins Deutsche übertragen von Dr. Max Huth. 180 pages, illustrations, plates, tables, 8vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper, 9 marks.

This work is issued as vol. 28 of the series "Monographien über angewandte Elektrochemie." It is a review of the rise and development of the electrochemical and electrometallurgical industries in Great Britain. A supplement contains the full text of eleven English patents covering all the branches of the industries excepting aluminum and calcium carbid. Being basic patents they are of special interest for the purpose of indicating the progress which has been made in the development of these branches of manufactures. A. R.

Illustrated Technical Dictionary in six languages: English, German, French, Russian, Italian, Spanish, compiled after a novel method by K. Deinhardt and A. Schlomann, Engineers. Volume 1, The Elements of Machinery, and the tools most frequently used in metal and wood working, by P. Stülpnagel. 403 pages, illustrations, 12mo. New York, McGraw Publishing Co., 1906. Price, in cloth, $2.00.

The authors announce a dictionary of technical words, to be complete in eleven volumes. It is intended that each volume shall cover some one department of science or industry. Volumes on hydraulic machinery, hoisting machinery, metallurgy, architecture and naval construction are in preparation. The first volume covers the elements of machinery and tools, and contains an appendix on engineering drawing and mechanics. There is a general index in five languages and a supplement containing the Russian terms. Simple drawings with references from the text make the work more comprehensive. R.

Bau einer modernen Lokomotive. Zweite, erweiterte Ansgabe mit 42 in den Text gedruckten Netzätzungen von Ingenieur Dr. Robert Grimshaw. 71 pages, illustrations, 8vo. Hannover, Published by the author, 1907.

This pamphlet describes in detail the construction of locomotives as carried on at the plant of the Baldwin Locomotive Works in Philadelphia. There are forty-two half-tones, which include views of the various shops and illustrations of the many types of locomotives and their parts.

A. R.

Sections.

Mechanical and Engineering Section.—Stated meeting held Thursday, December 19, 8 P.M. Mr. Chas. Day in the chair.

Present, eighty-six members and visitors.

The Chairman introduced Mr. Axel Welin, of London, England, who presented an address on "Life-Saving Appliances on Shipboard," fully illustrated with the aid of lantern pictures.

Mr. Welin's remarks related especially to the various means and appliances in use on shipboard for the handling of lifeboats, in the course of which he described some improvements of his own invention.

The subject was referred for investigation to the Committee on Science and the Arts. Adjourned.

Francis Head, *Sec'y.*

Mining and Metallurgical Section.—Stated meeting held Thursday, January 2, 1908, 8 P.M. President G. H. Clamer in the chair.

Present, sixty-three members and visitors.

The paper of the evening was read by Mr. Robt. W. Lesley on the subject of "Cements: their Use and Abuse," and was fully illustrated by lantern views. The paper was fully discussed and was referred for publication.

The speaker was voted the thanks of the meeting. Adjourned.

Wm. H. Wahl, *Sec'y pro tem.*

Section of Physics and Chemistry.—Stated meeting held Thursday, January 9th, 8 P.M. Dr. Robt. H. Bradbury in the chair.

Present, 118 members and visitors.

The paper of the evening was read by Mr. Chas. O. Bond, of the United Gas Improvement Co., of Philadelphia, on "Working Standards of Light, and their Use in Photometry." Mr. Bond's paper was a historical review of the subject of photometry, bringing it down to the present day. He illustrated his remarks by the exhibition of a variety of apparatus, and with lantern pictures. The paper was discussed by Dr. E. Goldsmith, Mr. Waldemar Lee, Mr. Walton Clark and the speaker. The paper was referred for publication, and the thanks of the meeting were voted to the speaker.

Adjourned.

Wm. H. Wahl, *Sec'y pro tem.*

Section of Photography and Microscopy.—Stated meeting held Thursday, January 30th, 8 o'clock P.M. Mr. Louis E. Levy in the chair.

Present, 109 members and visitors.

Mr. Morris Earle, of the firm of Williams, Brown & Earle, of Philadelphia exhibited and described the properties and advantages of a new Isostigmar Lens devised by Messrs. R. & J. Beck, of London.

Mr. J. E. Brulatour followed with a paper on a new method of color photography, now being exploited by the Lumiere North American Co., Ltd., of New York.

Mr. Brulatour illustrated his remarks by the exhibition of a number of lantern photographs showing the progress that has been made in the development of the Lumiere process.

Both communications were freely discussed.

On Dr. Griggs's motion both inventions were referred for investigation and report to the Committee on Science and the Arts.

M. I. Wilbert, *Sec'y.*

Section of Physics and Chemistry.—Thursday, February 6th, a stated meeting of the Section was held at 8 o'clock. Dr. Robert H. Bradbury in the chair.

Present, thirty-two members

The paper of the evening was read by Dr. Edward A. Partridge, on the subject of "The Electron Theory."

The paper was discussed by Dr. Edward Goldsmith, Dr. Bradbury, and the speaker of the evening.

Dr. Partridge was voted the thanks of the meeting and the session was adjourned.

Wm. H. Wahl, *Sec'y pro tem.*

Mining and Metallurgical Section.— A regular meeting of the Section was held on Thursday evening, February 13th, at 8 o'clock.

Present, thirty-four members.

Mr. G. H. Clamer in the chair.

The paper of the evening was read by Mr. Chas. L. Huston, President of the Lukens Iron and Steel Company, Coatesville, Pa.

The subject was, "Practical Experiments in Steel," and was fully illustrated. The paper was freely discussed.

The thanks of the meeting were voted to the speaker of the evening, and his paper was referred to the Committee on Publication. Adjourned.

Wm. H. Wahl, *Sec'y pro tem.*

The Franklin Institute.

Hall of the Institute,
Philadelphia, February 19, 1908.

Dr. Edward Goldsmith in the chair.

Present, fourteen members and visitors.

The Chairman introduced Dr. Chas. D. Thruing, of Philadelphia, who presented a paper on A New Radiation Pyrometer. The speaker illustrated his remarks by means of diagrams and apparatus.

The subject was referred, on motion, to the Committee on Science and the Arts for investigation and report. Adjourned.

Wm. H. Wahl, *Secretary.*

On Friday evening, February 14, a reception was tendered to the members and friends of the Institute by the Board of Managers and officers.

The entire building was thrown open to the visitors. The Library and Reading Room were handsomely decorated, and made specially interesting by the display of numerous models of machines, many of them having historic value, and by a fine and varied collection of photographs.

In the offices demonstrations were given with X-ray and other interesting physical apparatus.

Dr. Persifor Frazer addressed a large audience in the Lecture Room with a lecture on "The Franklin Institute: its Services and Deserts." The lecturer illustrated his address—which was an exhaustive historical sketch of the Institute, by the exhibition of a large number of lantern photographs, principally of those who have distinguished themselves in the service of the Institute.

A large number of members and friends were present, who thoroughly enjoyed the occasion.

The following is a list of models, photographs, etc., which were specially sent for exhibition:

EXHIBITORS' RECEPTION, FEBRUARY 14, 1908.

The Electrelle Co., Interior piano player.

The Victor Talking Machine Co., The Auxetophone.

Mr. S. Lubin, Motion pictures.

Roentgen Mfg. Co., X-ray apparatus.

Williams, Brown & Earle, X-ray apparatus.

The Philadelphia Electric Co., General lighting: tantalum and tungsten lamps; luminous radiators, electric fountain.

The Philadelphia Gas Works, Exhibit of photometric standards.

The Baldwin Locomotive Works, Model of "Old Ironsides," working model of Vauclain balanced compound valve motion.

The William Cramp Ship and Engine Building Co., Working model of hull of Clyde Line steamship.

Mr. J. Allen Heany, Heany tungsten lamps.

Goldschmidt Thermit Co., Specimens of Thermit welding.

American Cement Co., Specimens of cement.

K. & B. Co., Richard L. Binder, President, Electrical appliances.

The Welsbach Co., Lighting of hall and stairway by gas (Reflex lights).

The United Gas Improvement Co., Heating hall with Kane generators.

Cooper-Hewitt Electric Co., Two Cooper-Hewitt lights in lecture room.

PICTURES.

Baldwin Locomotive Works, Photographs of locomotives.

Mr. H. F. Colvin, Photographs of early locomotives.

American Cement Co., Illustration of the growth of the American Portland cement industry.

Mr. F. Gutekunst, Photographs of scientists.

Berry-Homer Co., Monster photographic enlargement.

Mr. W. N. Jennings, Photographs of lightning flashes, scenes in London, Paris, and Philadelphia, commercial work.

Dr. Chas. F. Himes, Photographs of historic documents.

Mr. W. J. Hammer, Photographs made with fire-flies and phosphorescence.

GENERAL PHOTOGRAPHIC WORK: VIEWS AND STUDIES.

Richard Gilpin, Dr. W. O. Griggs, Werner Kaufmann, I. P. Pedrick, J. W. Ridpath, W. H. Thorne, U. C. Wanner.

Specimens of work of the students of the Schools of Drawing and Naval Architecture.

JOURNAL

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OF THE STATE OF PENNSYLVANIA

FOR THE PROMOTION OF THE MECHANIC ARTS

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THE FRANKLIN INSTITUTE.

The Franklin Institute; Its Services and Deserts.*

BY DR. PERSIFOR FRAZER.

Professor of Chemistry of the Franklin Institute 1881-94.

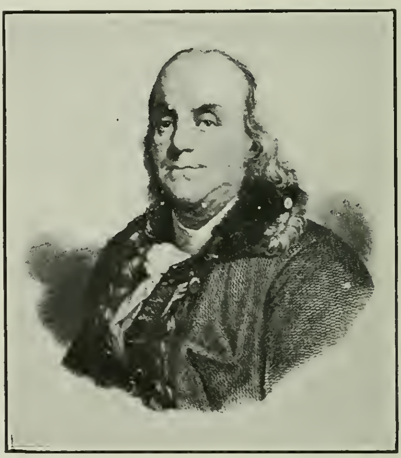
LADIES AND GENTLEMEN:—

The subject is difficult to treat in a worthy manner, because it has been treated at the fiftieth, the seventieth, and the seventy-fifth anniversaries of the Franklin Institute's birth by the Hon. Frederick Fraley, Dr. Coleman Sellers, Prof. Thurston, our Secretary, Dr. Wm. H. Wahl, and others; and because in these days lectures which are not filled with pictures (moving if possible) or experiments, to charm the eye, no longer satisfy the jaded public. The picture which this lecture is intended to present in its entirety is, however, a moving one in a spiritual sense; and I

*A lecture delivered before the Franklin Institute, on the occasion of the reception held Friday evening, February 14th, 1908, to formally inaugurate its reorganization following its receipt of the Benjamin Franklin Legacy.

wish to make it as moving as possible to overcome the lethargic indifference with which the beneficiaries of the work of others so often regard the struggles, and troubles, the hopes, crises, and efforts of their benefactors.

There is usually a Cinderella in each large family of children, and in the family of industrial and scientific societies of Philadelphia our Institute has filled the place of the oppressed sister at the domestic hearth. She has not yet arrived at the period where the prince selects her to share his happiness, but through a fairy godmother (Mrs. Anna W. Walker) the chance has come to prove



Benjamin Franklin (Duplessis painting)

that to the Institute belongs the glass slipper of Benjamin Franklin's legacy, and with it the blessings which that possession confers. The pumpkin and rats are now to be changed to a gilded coach and four; the rags to laces and diamonds; and the shabby kitchen to a palace; *provided* the good people of a city which, through lack of public spirit is rapidly losing prestige in all the directions in which it used to be peerless, will give its beneficent institution a part of the help it deserves.

To begin at a beginning which I have not seen referred to in the numerous sketches and histories of the Institute, I must believe, in the absence of contradictory information, that the reason for calling this Institute the FRANKLIN Institute was that its work was planned to realize the projects supported during the whole of

his busy life by that greatest of Americans, and so naively expressed in his incomparable will.* Here is the reproduction of the Duplessis painting of Benjamin Franklin. It may almost be said that the blessings we owe to his brain are as numerous and varied as the physical blessings we owe to the Sun. In his splendid invocation to the center of our system Tyndall says * * * *(XIIth Lecture on "Heat as a Mode of Motion," delivered in* 1862.*)* (The Sun.) " * * * is the source of all animal life and power. * * * Leaving out of account the eruptions of volcanoes and the ebb and flow of the tides, every mechanical action on the earth's surface, every manifestation of power, organic or inorganic, vital and physical, is produced by the Sun."

So with Franklin, whether we regard our educational inheritance in the University of Pennsylvania and the "Philadelphia publick library;" our charitable institutions, such as the Pennsylvania Hospital, and the loans to artisans; our physical defences in the militia system; or our higher associations for the diffusion of knowledge like the American Philosophical Society, we find all originated in the mind of this many-sided man.

The codicil to this will has been many times printed, and sometimes read, but it is so interesting that a few minutes may be profitably spent in referring to it. In language touchingly simple Franklin says: In a democratic state there should be no offices of profit; he gives his salary as President (Governor) to schools, churches, &c., and bequeaths £2000 to make the Schuylkill a navigable stream, but subsequently learning that this sum of £2000 would do little to effect this work, he revokes the bequest. He considers good apprentices most likely to make good citizens; and having, when himself a printer, been favored by two friends with loans, to which he ascribes his fortune and all that he has been able to accomplish, he gives £1000 to the city corporation, to be let out at interest at 5 per cent. per annum to such married artificers under the age of twenty-five years as have served an apprenticeship in the town, faithfully fulfilled the duties demanded by their indentures, and

*Dr. Coleman Sellers in his address as President of the Franklin Institute, closing its great exhibition of 1874, says: "Franklin, in memory of whose usefulness this Institute was named" * * * .

are guaranteed by two citizens as sureties in a bond with the applicants for repayment with interest of the money lent. These loans are intended to assist young men setting up their business. No one loan is to be more than £60 nor less than £15. Every year 1/10 of the principal shall be paid with interest. The managers are to take care of the business gratis, and the fund is to grow. He estimates it at £131,000 in one hundred years, of which £100,000 shall be laid out in public works, paving, building, etc., and for *bringing the water of the Wissahickon into the town to supply the inhabitants.* The remaining £31,000 is to be again let out at interest for another hundred years, when it ought to amount to £4,061,000, of which £1,061,000 is left to the disposition of the inhabitants of Philadelphia and £3,000,000 to the State of Pennsylvania.

The common thought which appears in Franklin's codicil and this Institute's constitution is the care for the young artificer, or mechanic.

HISTORY.

For some time before the founding of the Franklin Institute, in 1824, there had been numerous movements on foot to educate the working classes under the general designation of Mechanics' Institutes. Of this number was the Andersonian Institution of Glasgow.

An association of mechanics existed in Philadelphia in the late 'teens and early twenties of the last century, and the failure of our founder, Samuel V. Merrick, to be elected to this body is the cause of our present existence. The story is interestingly told by the late Hon. Frederick Fraley in his address at the semi-centennial ceremonies in 1874. After two false starts, Prof. Wm. H. Keating, of the University of Pennsylvania, and Mr. Samuel V. Merrick, with Dr. Robert E. Griffith and Geo. W. Smith, sent notices to some 1200 or 1600 citizens to meet at the County Court House, 6th and Chestnut Streets.

The meeting was largely attended. Mr. James Ronaldson, a Scot, who as a capitalist had founded a bakery, invested in cotton plantations, and was subsequently the owner of the largest type foundry in the United States, was called to the chair.

A committee was appointed to name officers and managers, and when the election was held the roll contained 400 to 500 members.

The first charter of the Franklin Institute of March 30th, 1824, enacts:

Sec. 1. "The Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts" is incorporated with a proviso that the yearly income of the real estate held by them shall not exceed $2000.

William Hypolitus Keating

Dr. William Hypolitus Keating was born in Wilmington, Del., August 11, 1799. and died in London, 1840. His ancestors had emigrated from Ireland to France to escape religious persecution and were ennobled by Louis XVI. His father, Baron John Keating, was a Colonel in the French army, stationed in the West Indies at the outbreak of the Revolution, when he resigned and settled in Wilmington, Del. William H. Keating graduated from the University of Pennsylvania in 1816, and studied in the polytechnic and mining schools of France and Switzerland. Returning to Philadelphia he was elected to the chair of Chemistry and Mineralogy in the University of Pennsylvania. He was geologist and historiographer of Maj. Stephen H. Long's second expedition, in 1723, to discover the source of the Mississippi. He afterwards read law and was sent to England to negotiate the first mortgage loan of the Reading Railway.

Sec. 2. The objects of the said corporation shall be the promotion and encouragement of manufactures, and the mechanic and useful arts, *by the establishment of popular lectures on the Sciences connected with them*,* by the formation of a cabinet of

*Italics the author's.

models and minerals, and a library, by offering premiums on all objects deemed worthy of encouragement, and examining all new inventions submitted to them, and by such other measures as they may judge expedient.

From the very first the supreme aim of the Institute was the instruction of artisans.

In the annual report of the Managers for 1838 it is said the manufactures of Philadelphia were infantile in 1824, when the Institute was founded, and exhibitions were then of great importance, but in 1838 the Arts had improved so vastly over the whole country that these exhibitions were no longer so necessary. It adds: "from earliest days the Franklin Institute contemplated establishing a school of Arts where the mechanic, miner, and civil engineer could receive instruction in all the sciences bearing on their several pursuits." Prof. Walter R. Johnson, the Principal of the High School of the Franklin Institute, published an able essay in the *Journal* of 1828 (p. 353) on the "combination of a practical and liberal course of education." Dr. John K. Mitchell in 1834 gave a thoughtful lecture on "the means of educating the character of the masses."

The Board of Managers again in 1841 in its annual report declares "the great department of the Institute is instruction."*

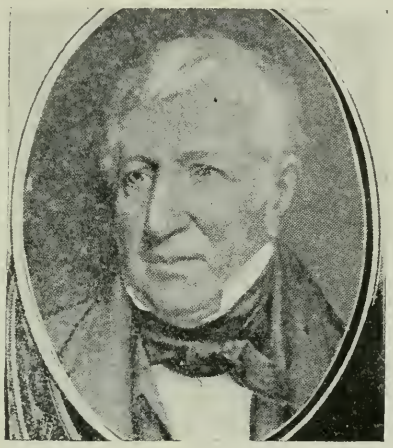
Under the heading "Regulations for the government of the committee on instruction," it is provided that the lectures shall begin the second Monday in November, and be continued on Monday, Wednesday, and Friday for twenty-one weeks, including the introductory lectures. The first week was to be occupied with introductory lectures, and was open to any who might please to attend, but to the remainder only those were admitted who had tickets; except strangers visiting the city, who might be admitted by a ticket from a member of the Committee on Instruction, or by consent of the Actuary. Tickets of admission were issued to every life-member; to ordinary members who paid their annual dues; to minors who were sons, daughters, wards, or apprentices

*Yet it was possible for the American Academy of Social and Political Science to discuss technical education in this city very recently without apparently remembering that the pioneer institute of this country in experiments of this kind was still enjoying a healthy existence but a short distance from its place of meeting, and might be able to contribute some experiences worthy the attention of the peripatetic body.

of the last class on payment of $1; and to pupils of the Drawing School without charge. Gentlemen not members paid $5 and ladies $2 each season.

The professorships were filled as follows: Chemistry, Wm. H. Keating; Natural Philosophy and Mechanics, Robert M. Patterson; and Architecture, Wm. Strickland.

Professors Keating and Patterson held chairs in the University of Pennsylvania, as did the subsequent Professors of the Institute, Alex. Dallas Bache, John F. Frazer, Henry Reed, Roswell Park, Robert Hare, and the brothers James and Robert E. Rogers.



James Ronaldson

Mr. James Ronaldson was born upon his father's estate, "Georgie," near Edinburgh, Scotland, in 1770. He came to Philadelphia in 1791, and not wishing to be idle he bought an interest in a biscuit bakery, which he maintained for nearly two years, when he entered into partnership with Andrew Binney, in 1794, to manufacture type of various kinds, which was the beginning of the type-founding business in America. This business later on developed into the McKeller, Smith & Jordan Co. of the present time.

James Ronaldson engaged later on in spinning cotton yarns. He owned the "Hillsburg Mills" of 1200 spindles—located on Ridley Creek, fifteen miles below Philadelphia. Ultimately he established the Philadelphia (now the Ronaldson's) Cemetery, to afford citizens of small means decent burial at charges within their means. This was the first cemetery outside those around the church-yards in the city. The west-end walk ground was free to worthy persons who were in straitened circumstances and poor.

He established the first Night School in the Southwark District, and also the first Soup Society for the poor. He had the soup made in a room

or kitchen in the rear of his house, where he could at any time test its quality by having samples brought to his table.

He was President of the Mechanical Society, which preceded the Franklin Institute by many years, and eventually was its nucleus. This Society had its rooms on the west side of Third Street, a few doors below Market Street, in the second story in the rear.

He was a personal friend of President Andrew Jackson, but refused a seat in his Cabinet.

He was the President of the Louisville Canal Company, and it may be of interest to add that he had in his employ, as one of his Engineers, the late J. Edgar Thompson, whom he subsequently sent to the Pennsylvania Railroad Company, of which Thompson eventually became President. He was the first President of the Franklin Institute, and occupied the office from 1824 till his death, in 1841.

Franklin Institute Facade before 1830

The first course of lectures was delivered in the old Academy building, belonging to the University of Pennsylvania, in Fourth Street near Arch. Soon a school of Architecture and Mechanical Drawing was established. Among the first pupils was Thomas U. Walter, then a bricklayer, but, thanks to that school, afterwards the architect of Girard College, and ultimately of the Capitol at Washington.

Then a special school of English Literature, Ancient and Modern Languages, Mathematics—a veritable high school—was placed under the direction of Walter R. Johnson.

The corner stone of the present building was laid with appropriate Masonic rites June 8th, 1825.

A better idea can be had of the phenomenal growth of this Institute by running over some of the most important events of its early life than by any other means.

The Institute set out with almost the organization it has at present. An exhibition was held in Carpenters' Hall the first year (1824), and a journal was started the next year largely under its auspices though not owned by the Institute until a couple of years later. This journal was called "The Mechanical Magazine, Register, Journal and Gazette."

Its opening page contains a large wood cut of a pit saw, and further on are cuts of a chemical engine, invented by Captain Munby, of London, for immediate service on the alarm of fire, which is not materially different from those in use to-day. On the cover of the first number it is requested that communications be addressed to James V. Seaman, Broadway, New York. Wm. Van Norden was the printer. In Vol. II was published the prospectus of the new Journal, into which this was to be merged, to be called "The Franklin Journal and American Mechanics Magazine," edited by Thos. P. Jones. In 1826 the membership had increased from 560 to 1065.

This building 60′ x 100′, had been nearly completed, and the second story rented to the United States Marshall for the use of the District Court, on a lease of ten years. The whole expense of the building was $35,000. In 1826, the courses of instruction included Chemistry, Mechanics, and Natural History, besides volunteer lectures on miscellaneous subjects.

Dr. Thomas P. Jones, the Editor of the *Journal*, filled the chair of Mechanics. It is not easy to estimate adequately the services of this distinguished member of the Institute. He conceived and founded at his own expense the *Journal* by which the Institute is principally known abroad, and which accomplished more to establish the high reputation of the Institute in foreign lands than any other thing. He conducted this journal with signal ability for twenty-three years (1825 to 1847, inclusive) and impressed upon it the character it has ever since retained. During its early years and up to the

period of development of the Sections, largely through the pertinacious efforts of our present Secretary, Dr. Wm. H. Wahl, the aim of the *Journal* was to reprint the most important articles and papers on scientific subjects which appeared in all countries, on the plan so successfully adopted by Littell's Living Age for literary material. At that time, when the transactions of learned societies, and the scientific publications of foreign countries were difficult to procure, this scientific digest was of immense importance to American scientific men; of much greater importance indeed than any single volume from which excerpts were made; because it placed at the disposal of research men and practical me-

Thomas P. Jones

chanics, information of discoveries and inventions all over the world and up to date, which it would have been impossible for them to procure otherwise. At the same time it laid a heavy burden of expense upon the Editor, and required of him a rare power of selection, conditions fulfilled both by Dr. Jones and by Professor John F. Frazer who, after an interregnum of two years filled by the Committee on Publication, followed him in the Editorship, and retained it for seventeen years. It is not readily realized at the present time when one can consult the scientific publications of many countries in a dozen societies or public libraries, that at that time, say up to 1865, one was obliged to subscribe in order to obtain access to them. And this was done wholly at

his own personal expense, by each of the first two editors of the *Journal.* A school for Mathematics, under Prof. Jos. P. Espy,* and a Drawing School were also added.

Amongst others, at the exhibition of 1826, Thos. Harrison received a medal for a box of "rose pink of very superior quality." October 26, J. Redman Coxe presented to the Institute "the electrical machine belonging to the immortal Franklin." The high school of the Institute was working well. Evening schools for drawing were begun October 19, 1826. Another exhibition was held for four days in Masonic Hall.

Franklin Institute Drawing School in operation (Recent)

At the 4th annual exhibition in Masonic Hall, October 4 to 8, 1827, tickets were sold at $12\frac{1}{2}$ cents apiece. Members were admitted with two ladies free, but in spite of this low price the Institute was enriched by $738.21. In 1828, the net earnings were $715.

*James Pollard Espy was born in Westmoreland County, Pa., May 9th, 1788, died in Cincinnati, Ohio, January 21st, 1860. He graduated from Transylvania University in 1808 and shortly after became principal of an academy in Cumberland. Admitted to the bar, he accepted the chair of Mathematics in the Franklin Institute. He published the first of his observations on meteorology in its journal. His theory of storms was received favorably by both the French Academy and the British Association for the Advancement of Science, before which latter body he presented his views in 1840. In 1843, he received an appointment in the War Department, and there first began a service of daily bulletins in conjunction with the newspapers and telegraph companies. He received from the American Philosophical Society in 1836 the Magellanic Medal and Premium.

In 1828, the *Journal* was transferred by its owner and editor Dr. Jones, to the Franklin Institute, which retained him in the latter office. Mr. William Hamilton was appointed Actuary by the Board of Managers at a salary, and served the Institute faithfully till his death, forty years later. Dr. Jones resigned the chair of Mechanics to accept the Superintendency of the Patent Office at Washington, but still retained the editorship of the *Journal* and made it the vehicle of the official publication of all patents issued by the Government.

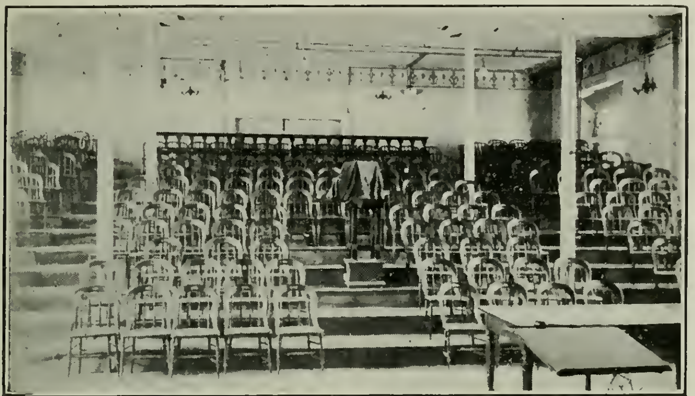
One of the most notable articles in the *Journal* of this year (p. 352) was the "Combination of a Practical and Liberal Course

William Hamilton

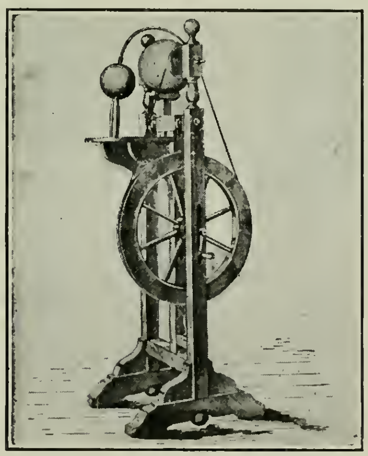
of Education," by Prof. Walter R. Johnson, Principal of the High School of the Franklin Institute.* In 1829, the title of the

*Walter Rogers Johnson was born in Leominster, Mass., June 21st, 1794, and died in Washington, D.C., April 26th, 1852. He graduated at Harvard 1819; following which he taught school in Massachusetts, and still later was Principal of an Academy in Germantown, Philadelphia. He was Principal of the Franklin Institute High School, and filled the chairs of Mechanics and Philosophy. In 1836 he began a series of geological investigations as to coal and iron ore. In 1837 the United States Government put him in charge of magnetic, astronomical, and electrical investigations of an expedition prepared in that year, but he relinquished it. From 1839 to 1843 he was in charge of the department of Physics and Chemistry in the University of Pennsylvania. In 1843 he was commissioned by Congress to investigate the steam-raising qualities of various coals, and produced a work of great value even to the present day. He afterwards was employed by the United States Navy, and then was attached to the Smithsonian Institute, and was sent to the World's Fair in London, in 1851.

Journal was changed to the "*Journal of the Franklin Institute,*" &c. The Circuit Court expressed anxiety at the stability of the floor it occupied, which was thereupon strengthened by four cast-iron columns. Monthly meetings were instituted. At a meeting of the Board a committee was appointed to undertake an investiga-



Franklin Institute Lecture Room



Franklin's Electrical Apparatus.

tion of the efficiency as a motor of moving water, the first of a series of researches undertaken by the Institute, which like each of the later investigations of the causes of explosion of steam boilers, &c., attained the dignity of a classic in the literature of science and conferred great distinction on the Institute.

It was decided in 1829 to make the exhibitions biennial instead of annual.

In 1830, it was determined to have a certificate of membership, and the design of the certificate was entrusted to America's great artist, Thomas Sully.

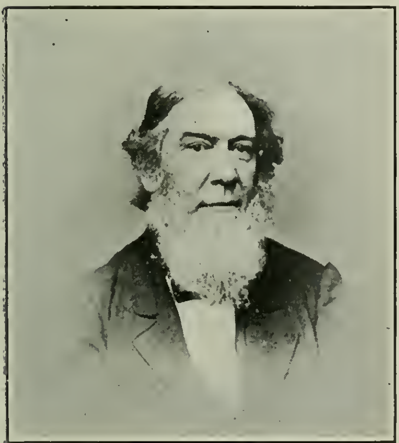
At a meeting June 10th of this year, the Board appointed a committee consisting of Wm. H. Keating, Robert Hare,* Samuel V. Merrick, Alex. Dallas Bache, Isaiah Lukens, Jas. J. Rush, James Ronaldson, Frederick Graff, Robert M. Patterson, J. K. Mitchell, Benj. Reeves, Geo. Fox, Thos. P. Jones, Walter R. Johnson, Matthias W. Baldwin, Jas. P. Espy, and George Merrick to inquire into the causes of the explosions of steam boilers—a notable body indeed, whose services any institution might be proud to command.

In 1824, the Professors and Instructors had been Dr. Wm. M. Keating, of the University of Pennsylvania, Chemistry; Dr. Thos. P. Jones, Mechanics; Dr. Godman, Natural History; Wm. Strickland, Architecture. James P. Espy, who later won undying fame for his investigation of storms, directed a school for Mathematics, and there was one for Drawing. Dr. Franklin Bache replaced Dr. Keating in the Professorship of Chemistry in

*Robert Hare, born in Philadelphia January 17th, 1781, died there May 15th, 1858; was the son of an Englishman who established a large brewery in Philadelphia. He attended lectures on Chemistry and Physics in Penn's city, and before his twentieth year became a member of the Chemical Society of Philadelphia, to which he communicated his discovery of the oxy-hydrogen blowpipe in 1801. He invented the valve cock or gallows-screw for opening communication between separate pieces of apparatus with perfect exclusion of air. In 1816 he invented the calorimotor, later perfected as the deflagrator, for producing great heat by a battery. As a chemist he devised a means of denarcotizing laudanum and detecting minute quantities of opium in solution. In 1818 he was called to the chair of Chemistry in William and Mary College, Va., and in the same year was elected to the Professorship of Chemistry in the University of Pennsylvania (Medical Department), His experiments were noted all over the world for their originality and their large scale. He was a prolific contributor to the scientific journals (especially Silliman's, in which he published 200 papers) and to journals of general scope like the "Portfolio," to which he contributed under the pen-name of Eldred Grayson, a series of articles on Moral Philosophy and Economics. In his latter years he embraced the doctrine of Spiritualism, and published in 1855, New York, a book entitled "Spiritualism Scientifically Demonstrated."

1826. With minor changes this arrangement lasted till 1831, when Franklin Peale, one of the gifted sons of Chas. Willson Peale, divided the curiously combined course of Mechanics and Natural History with Prof. Walter R. Johnson, who took the former subject.

In 1832, another commission was appointed to examine into the resources of Pennsylvania—an action which led to the geological survey of a few years later. Professor Johnson made his name immortal by his report on the steam-raising power of coals, presented to the Secretary of the Navy, Mr. Mason, in 1843. He had been in charge of the Franklin Institute High School, and had replaced Dr. Jones in the chair of Mechanics.



Alexander Dallas Bache

John Kearsley Mitchell

Alexander Dallas Bache, born in Philadelphia July 19th, 1806, and died in Newport, R. I., February 17th, 1867. He was the son of Richard Bache and Sarah, daughter of Benjamin Franklin. From his first education in a classical school of Philadelphia he showed marked aptitude for learning. He entered the United States Military Academy at West Point at fourteen and, though the youngest member, graduated at the head of his class in 1825, without having received a single demerit. He was retained at the Academy after graduation as Assistant Professor of Engineering, with the rank of First Lieutenant. In 1829 he served under Colonel J. C. Totten as Assistant Engineer in the construction of Fort Adams, at Newport, R. I., but resigned from the army in that year. In 1828 he was called to the chair of Natural Philosophy and Chemistry in the University of Pennsylvania, which he filled till 1841. On returning to Philadelphia in 1841, he became interested in the work of the Franklin Institute, and aided it with all his zeal and learning. In 1836 he was entrusted with the organization of Girard College,

became its first President, and spent some time in Europe studying educational systems for the purpose of applying them to the institution. In 1841-2 he was Principal of the High School and Superintendent of the Public Schools of Philadelphia. His system has been adopted by many cities. During this time he established the first magnetic and meteorological observatory on the Girard College grounds. In 1843 he was made Superintendent of the United States Coast and Geodetic Survey, which office he filled till his death. During the Civil War he was chief engineer of the defences of Philadelphia. He was one of the incorporators of the Smithsonian Institution in 1846 and annually thereafter was reëlected by Congress. He was given the degree of LL.D by the University of New York in 1836; University of Pennsylvania in 1837; and Harvard in 1851. He was President of the American Philosophical Society and one of the incorporators and founders of the National Academy of Science, as well as its first President He was an Honorary Member of the Royal Society of London; the Institute of France, the Royal Academy of Turin, &c.; yet all of these titles and activities do not adequately express all that he was. He was the embodiment of the highest type of scientific man which America has produced, set in the person of the kindliest and most courteous gentleman.

:John Kearsley Mitchell, born in Shepardstown, Jefferson County, Va., May 12th, 1798, died in Philadelphia April 4th, 1858. He was educated at Ayr and Edinburgh, Scotland, from the age of eight years till his return to America, where he studied medicine under Dr. Nathaniel Chapman, and graduated from the University of Pennsylvania in 1819. He made three voyages to China as ship surgeon, but settled in Philadelphia in 1822. In 1824 he was lecturer at the Philadelphia Medical Institute, and was made Professor of Chemistry at the Franklin Institute in 1833. In 1841 he became Professor of the Theory and Practice of Medicine in Jefferson Medical College. He was a practitioner of medicine highly esteemed and, like his distinguished son, Dr. S. Weir Mitchell, an author of valuable scientific works as well as of poetry and prose fiction.

Nothing strikes one more forcibly than the versatility of the gentlemen who composed the teaching force in the Franklin Institute. Prof. Johnson published in 1832 a notable paper in the *Journal* on the strength of steam boilers. In this year the Secretary of the Treasury requested a further extension of the inquiry to include the prevention of steam boiler explosions. Dr. J. K. Mitchell replaced Franklin Bache as Professor of Chemistry.

In 1833, steel from American iron was exhibited by Karthause, of Baltimore, as a curiosity, and Mr. T. Fletcher showed an "instrument called a chronograph," by Fatton, of France. Dr. Robert Hare showed the model of his double acting air pump.

In 1834, Gouverneur Emerson, M. D., gave his second course on Meteorology. J. Millington, of the Royal Institution of Great Britain, gave a course on Astronomy; Prof. Henry D. Rogers a special course on Chemistry. The drawing school was placed under Wm. Mason, and the English school under Seth Smith. The name of the Committee on Inventions was changed to that of "Committee on Science and the Arts," as at present. The Secretary of the Commonwealth of Pennsylvania presented the Commonwealth's thanks for the report on weights and measures received from the Institute.

In 1835, Titian Peale, another son of C. Willson Peale, described a means to protect butterflies in a collection from injury, and showed a model of Redheffer's perpetual motion,—through a spring concealed in one of the columns of support. Prof. A. D. Bache showed Prof. Henry's spark from a single galvanic pair. The Committee on Science and the Arts reported on Baldwin's locomotives. The Institute determined to sell this hall and purchased the Masonic Grand Lodge Building, in Chestnut Street above Seventh, on the site now occupied by the building erected by the late Wm. M. Singerly. A copy of the claim by Thos. Jefferson for the invention of rendering salt water fresh by distillation was published.

In 1836, the words "and Mechanics' Register" was added to the title of the journal. The name of John C. Cresson first appears in the columns of the *Journal* as having shown a specimen of Alabama cotton in the pod.

Prof. Alex. Dallas Bache presented the ingenious reasoning of Benj. Franklin to explain why the rain- and hail-fall near the surface of the earth is greater than at heights. (Letter to Dr. Percival of 1764), and Mr. Featherstonhaugh was criticised for calling himself "United States Geologist."

The second joint report of the American Philosophical Society and the Franklin Institute on Meteorology was printed; also the "Franklin Kite Club's experiments on atmospheric electricity," John C. Cresson, Chairman. An interesting note appeared on Berzelius' definition of the new force he called "Catalysis." John F. Frazer and J. C. Trautwine presented minerals. Jas. C. Booth lectured on Arts and Manufactures. A note is given on the Filtration of Heat from Solar Rays, by Melloni, and by Dr. Draper, of Hampden-Sidney College, Va., and on Actinism, by

Mrs. Somerville. John C. Cresson was elected to the chair of Mechanics, and McClure to that of "Architecture and Practical Carpentry." Metallic pens tipped with Osmium, by J. J. Hawkins, of London, were shown by Franklin Peale.

On the cover of the *Journal* was printed, "3 sheets under 100 miles 4½ cts, over 100 miles 7½ cts."

John Fries Frazer

John Cresson Trautwine

John Fries Frazer was born in Philadelphia July 8th, 1812, and died there October 12th, 1872. Residing with Dr. Samuel B. Wylie, of Philadelphia, his early education was obtained at Dr. Wylie's classical Academy and at Col. Partridge's Military School, in Norwich, Conn. He graduated from the University of Pennsylvania in 1830, sharing the first honor with the Rev. James Clark. He studied medicine, but though well prepared he did not apply for examination. He studied law and was admitted to the bar. He was first assistant Geologist of the first Geological Survey of Pennsylvania in 1836, and assistant of Professor A. Dallas Bache and Dr. Robert Hare in the University of Pennsylvania. He was Professor at the High School, Professor of Natural Philosophy and Chemistry at the University of Pennsylvania 1844-72. Vice-Provost of the University and Vice-President of the American Philosophical Society, 1855-68, when he resigned both offices. He was one of the incorporators of the National Academy of Science in 1863. He received the degree of LL.D from the University of Lewisburg in 1855, and from Harvard in 1857.

He was the author of many complete treatises on Chemistry, Physics, and Mechanics, which, however, he always printed privately and distributed to his students to assist them in the numerous courses of lectures which he delivered in the University of Pennsylvania and the Franklin Institute.

John Cresson Trautwine was born in Philadelphia March 30th, 1810, and died there September 14th, 1883. In 1828 he entered the office of Wm.

Strickland and soon thereafter designed and superintended the construction of the Penn Township Bank, assisted in constructing the United States Mint, and was engaged in constructing the Columbia Railroad in 1831. He was principal engineer of the Philadelphia, Wilmington & Baltimore Railroad, Philadelphia & Trenton, and of the Hiawassee Railroad of Tennessee to Georgia during the years 1835 to 1842. From 1846 to 1849 he was associated with George M. Totten in the construction of the canal del Dique and the Panama Railroad. He was actively engaged in Porto Rico, Pennsylvania, Montreal, and other places in great engineering works till 1864. He made the most important contributions to the literature of engineering in the professional journals, besides adding to the permanent literature tables and methods of calculation which are prized all over the world. His Civil Engineer's pocket book, originally published in 1872, has passed through the eighteenth edition and eighty-fourth thousand (1906) by the labors of his son and grandson of the same name, and is an almost encyclopædic treasury of all data bearing on the profession of engineering.

In 1838, Prof. E. Otis Kendall's Reduction of Solar Eclipses were published. The Committee on Uniformity of Weights and Measures printed its valuable report. A note from an English journal recorded that Mr. Walter Hancock, steam-car engineer, accompanied by two friends, rode from Stratford to Guildhall, London, in a steam gig, and threaded his way in Cheapside through the throng of carts and wagons without difficulty. This was the first automobile. Dr. John K. Mitchell described an apparatus devised by himself for repeating Thillonier's experiment of liquefying CO_2.

1839. In spite of the prostration of business in 1837 and the consequent failure of the Franklin Institute to dispose of its costly purchase of the Masonic Temple, the rents from tenants in that building paid costs of interest on the investment. Among foreign notes is Arago's announcement to the Institute of France of "photogenic drawings" by Dauguerre. The word "photograph" was first used by Sir John Herschel. Mosander announced a new metal, "Latanium," which has since failed to materialize. A screw propeller was first used to move the "Archimedes," of 230 tons along the English coast. Geary made an artificial fuel like modern briquettes. Dr. Robert Hare showed his new Eudiometer.

1840. Prof. A. D. Bache's report on Education, prepared from notes in Europe during a voyage undertaken for Girard College, was published in the *Journal*. A description of the Philadelphia & Columbia Railroad by W. H. Wilson is interesting. The

road started at Broad and Vine Streets, Philadelphia, and ended in the Borough of Columbia on the Susquehanna. Its route was from Broad to Vine, N. E., passing Fairmount Water-works; parallel to the Schuylkill, which it crossed three miles from the city, and mounted an incline plane (Belmont) 2805 feet long and 187 feet high. Thence it followed "the dividing ridge between the Delaware and Schuylkill" (?) 19 miles, &c. John F. Frazer gave a course of lectures on Geology. Dr. Robert Hare announced that in passing from vapor to snow, water would impart

Frederick Fraley

Samuel Vaughan Merrick

Frederick Fraley was born in Philadelphia May 28th, 1804, and died there in 1901. After studying law he engaged in business. He was one of the founders of the Franklin Institute and for many years its Treasurer. He was elected to City Councils in 1834, and as chairman of its finance committee in the panic of 1837 proposed the successfully adopted expedient of issuing certificates of indebtedness in small denominations. In this year he was elected to the State Senate. On the completion of Girard College, in 1847, he became one of its trustees. He was one of those who brought about the consolidation of the city in 1854. He was one of the founders of the Union Club (afterwards Union League). He was a delegate to the Boston Commercial Convention for the establishment of a National Board of Trade in 1868, and was chosen President of this Board annually till his death. He was one of the most active promoters of the Centennial Exposition in Philadelphia and was Treasurer of the Board of Finance. He was elected a member of the Board of Trustees of the University of Pennsylvania in 1853, and President of the American Philosophical Society in 1879, retaining these offices until his death.

To a profound knowledge of affairs and of men he added a singular apti-

tude for the duties of presiding officer of a deliberative body, and to the very end of his long and useful life he retained the power of accurate memory and felicitous expression, which distinguished him throughout his career.

Samuel Vaughan Merrick was born in Hallowell, Maine, May 4th, 1801. In 1816 he came to Philadelphia and entered the counting house of his uncle. At the age of twenty-three he was one of the founders of the Franklin Institute, and was its President from 1852 to 1855. He studied engineering, and in 1836 established in South Philadelphia the Southwark Iron Foundry, which became the best works of the kind in the country. He was elected a member of Councils of Philadelphia, was sent to Europe to investigate the method of using illuminating gas, and aided in having it introduced into Philadelphia. He was a member of the American Philosophical Society from 1833 till his death, which occurred in Philadelphia August 18th, 1870.

as much heat to the air as twice its weight of red hot powdered glass. The collaborators of Dr. Thos. P. Jones in editing the *Journal* were now, John C. Cresson, James C. Booth, John F. Frazer, J. Griscom, Thomas U. Walter, J. C. Trautwine, A. D. Bache, Sears C. Walker, Samuel V. Merrick, Frederick Fraley, Thompson S. Browne, W. H. Emory, Ellwood Morris, Sol. W. Roberts and Thomas F. Moss.

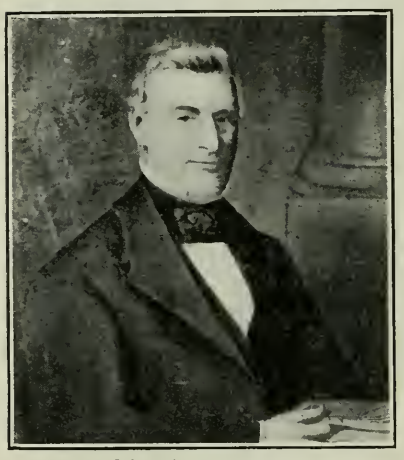
The closing address of the very successful exhibition of 1845 was made by John F. Frazer.

The following is a list of the officers of the Institute since its foundation:

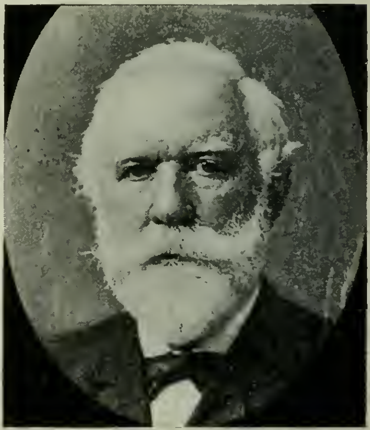
Presidents.—James Ronaldson, 1824 to 1842; Samuel V. Merrick, 1842 to 1855; John C. Cresson, 1855 to 1864; William Sellers, 1864 to 1867; J. Vaughan Merrick, 1867 to 1870; Coleman Sellers, 1870 to 1875; Robert E. Rogers, 1875 to 1879; William P. Tatham, 1879 to 1886; Chas H. Banes, 1886 to 1887; Joseph M. Wilson, 1887 to 1897; John Birkinbine, 1897 to 1907; and Walton Clark, 1907 to date. It is the hope and belief of the friends of the Institute that our present President is the Moses who is to lead the faithful supporters of this institution out of the Seventh Street wilderness into the promised land of the Fairmount Park Boulevard.

Vice-Presidents.—Matthew Carey, 1824 to 1829; Paul Beck, Jr., 1824 to 1828; Thomas Fletcher, 1828 to 1853; Isaiah Lukens, 1829 to 1846; Abraham Miller, 1846 to 1855; John Agnew, 1851 to 1864; Matthias W. Baldwin, 1855 to 1864; John H. Towne,

1864 to 1869; Fairman Rogers, 1864 to 1867; John F. Frazer, 1865 to 1867; Coleman Sellers, 1867 to 1870; Robert E. Rogers, 1868 to 1875; Bloomfield H. Moore, 1869 to 1875; H. G. Morris, 1870 to 1875; George Ereby, 1867; Chas S. Close, 1875 to 1880; Frederick Graff; Joseph E. Mitchell, 1876 to 1888; Henry Cartwright, 1880; Wm. P. Tatham, 1888 to 1900; Edw. Longstreth, 1892 to 1895; S. Lloyd Wiegand, 1892 to 1895; H. R. Heyl, 1895; Theodore D. Rand, 1900 to 1906; George V. Cresson, 1901 to 1904; Henry Howson, 1904 to date; Washington Jones, 1902 to date; James M. Dodge, 1905 to date.



John Chapman Cresson



William Sellers

John Chapman Cresson was born in Philadelphia in 1806 and died there in 1876.

He was educated in the Friends' Academy, attended lectures in the University of Pennsylvania. In 1834, he engaged in business in Philadelphia and was made Superintendent and Engineer of the Philadelphia gas works, which office he held for twenty-eight years.

He was given the chair of Mechanics and Natural Philosophy in the Franklin Institute in 1837, and held a similar office in the High School for two years. He was for many years a Manager and Vice-President of the Pennsylvania Institute for the Blind, and was connected with many other charitable institutions. He was a Manager of the Schuylkill Navigation Company, President of the Mine Hill & Schuylkill Haven Railroad Company 1847-76, and one of the original Fairmount Park Commissioners after serving as Chief Engineer of that park.

William Sellers was born in Upper Darby, Philadelphia, September 19, 1824, educated at a private school, apprenticed to his uncle as a machinist

in 1838. In 1845 he was made Superintendent of the Fairbanks and Bancroft Machine Works, in Providence, R. I. In 1848, Bancroft & Sellers formed a partnership in Philadelphia till 1855, when the firm changed to Wm. Sellers & Co. He was elected President of the Franklin Institute in 1864; in 1868 Trustee of the University of Pennsylvania; in 1873 member of National Academy of Science. He died in Philadelphia January 24, 1905.

Secretaries.—(Recording and Corresponding till 1865.)

Recording.—William Strickland, 1824 to 1827; T. P. Jones, 1827 to 1829; Algernon E. Roberts, 1829; James H. Bulkley, 1830 to 1833; W. S. Perot, 1833 to 1835; John C. Trautwine, 1835 to 1837; I. B. Garrigues, 1837 to 1864; Washington Jones, 1864.

Corresponding.—P. A. Brown, 1824 to 1828; Isaac Hays, 1828 to 1839; A. D. Bache, 1839 to 1844; Ellwood Morris, 1844; John F. Frazer, 1845 to 1847; Solomon W. Roberts, 1847 to 1854; John C. Cresson, 1854; Frederick Fraley, 1855 to 1864; Robert Briggs, 1864.

Recording and Corresponding Secretaries were replaced by one Secretary from 1864.

Secretary.—Henry Morton, 1868 to 1871; Wm. H. Wahl, 1871 to 1875; J. B. Knight, 1875 to 1880; Isaac Norris, 1880 to 1882; Wm. H. Wahl, 1882 to date.

Treasurer.—Thomas Fletcher, 1824 to 1826; John Richardson, 1826 to 1828; Samuel V. Merrick, 1828 to 1830; Frederick Fraley, 1830 to June, 1847; C. B. Trego, June, 1847, to 1848; John F. Frazer, 1848 to 1865; Frederick Fraley, 1865 to 1883; Samuel Sartain, 1883 to 1907; Wm. H. Wahl, 1907; Cyrus Borgner, 1908 to date.

Actuary.—William Hamilton, 1828 to April, 1871; Wm. H. Wahl, to 1872; David S. Holman, 1872 to 1885; H. L. Heyl, 1885 to 1908.

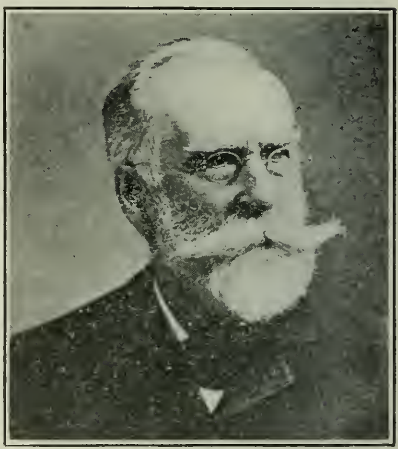
Among the earlier Professors, instructors, and lecturers have been Wm. M. Keating, Thos. F. Jones, D. Godman, Wm. Strickland, Franklin Bache, J. K. Mitchell, Franklin Peale, William Mason, John McClure, H. D. Rogers, James P. Espy, James C. Booth, John C. Cresson, John F. Frazer, J. Rufus Mason, Thomas U. Walter, Robert E. Rogers, and many more.

Editors of the Journal.—Thomas P. Jones, 1825 to 1847; Committee on Publications, 1848 and 1849; John F. Frazer, 1850 to 1867; Henry Morton, 1867 to 1870; H. Morton and Wm. H.

Wahl, 1870 to 1871; Wm. H. Wahl, 1871 to July, 1874; George F. Barker, July, 1874, to July, 1875; Robert Briggs, July, 1875, to 1877; Committee on Publication to date.

Among the distinguished members of and workers for the Franklin Institute should be named: John Sartain, Frederick Graff Charles Bullock, Henry C. McCook, Harvey Washington Wiley, George W. Melville, Robert H. Thurston.

John Vaughan Merrick



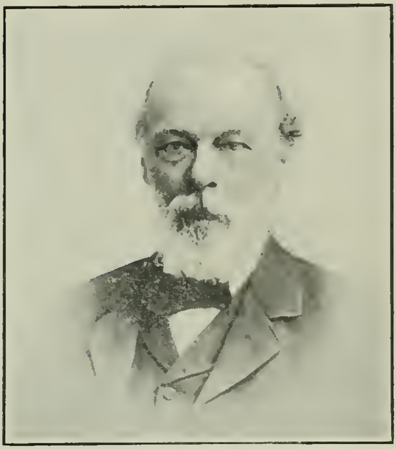
Coleman Sellers

John Vaughan Merrick was born in Philadelphia April 30, 1828; graduated at the Central High School 1843. Studied engineering in Philadelphia works. He was a partner in Merrick & Sons, founded by his father; Vice-President of the Zoölogical Society of Philadelphia 1886; President of the Free and Open Church Association; Trustee of the University of Pennsylvania from 1870 till his death, and Vice-President of the American Society of Mechanical Engineers from 1883 to 1885. He died in Philadelphia March 28, 1906.

Coleman Sellers was born in Philadelphia January 28th, 1827, and died there December 28th, 1907. He was educated by his mother, at the school of the Franklin Institute, and by Bolmar, in West Chester, Pennsylvania. In his nineteenth year he went to the Globe rolling mill, Cincinnati, Ohio, for three years, during part of which time he was Superintendent. He then served with Niles & Co. for five years in the manufacture of locomotives. In 1856 he returned to Philadelphia and became Chief Engineer of William Sellers & Co.'s works until 1888, when he retired from active direction in the firm and devoted himself to private practice. He obtained more than thirty patents for inventions, many of which of universal application. He was Professor of Mechanics at the Franklin Institute for twenty-three years. On his retirement from active practice the Stevens Institute of

Technology, at Hoboken, N. J., created a chair for him of Engineering Practice, and in 1887 he received from that institution the degree of Doctor of Engineering. In 1889 he reported on the practicability of generating power at Niagara Falls. Subsequently he was made Chairman of the Cataract Construction Company, participated in the organization of the International Commission in London, where his colleagues were Lord Kelvin, Turrettini, Mascart, and Unwin. He was made chief engineer of the construction company, succeeded against the views of Lord Kelvin in convincing the Commission of the advantage of an alternating current, and carried the enterprise to a splendid commercial success.

Robert Empie Rogers



William Penn Tatham

Robert Empie Rogers was born in Baltimore, Md., March 29, 1813. Educated by his father and afterwards by his brothers. He intended to become a civil engineer, and was assistant in the survey of the Boston & Providence Railroad. He abandoned this work in 1833 and graduated in the medical department of the University of Pennsylvania in 1836, taking the full course in chemistry under Dr. Robert Hare. In 1841-2 he was instructor in Chemistry at the University of Virginia. In 1852 he replaced his brother, James, as Professor of Chemistry in the University of Pennsylvania, becoming dean of the Medical Faculty in 1856. In 1877 he became Professor of Chemistry and toxicology at Jefferson Medical College, Philadelphia, and became Professor emeritus there in 1884. During the civil war he was Acting Assistant Surgeon, stationed at the West Philadelphia Military Hospital. He received the degree of LL.D. by Dickinson College in 1877. He was one of the incorporators of the National Academy of Science, and President of the Franklin Institute from 1875 to 1879. He died in Philadelphia September 6, 1884.

William Penn Tatham, who died on August 5, 1899, was born near Frankford, Philadelphia, in the year 1820. In 1840, he and his brothers

formed a partnership for the purpose of manufacturing lead pipe and sheet lead. The most important feature of their business was the introduction into this country of solidly-drawn lead pipe. On his return home, in 1850, he became a member of the Franklin Institute; in 1870 he was elected a member of the Board of Managers, and in 1879 was elected to the Presidency of the Institute, and held that position until the end of 1885. He was then re-elected a member of the Board of Managers, and in 1887 was elected one of the Vice-Presidents, and continued in that office until failing health caused his retirement in 1897. During his long connection with the Franklin Institute he was constant in his devotion to the advancement of its objects, and identified himself with all its important transactions. For fifteen years Mr. Tatham held the congenial position of Chairman of the Committee on Library. He was Chairman of the Committee on Exhibitions in 1874, on the occurrence of the semi-centennial anniversary of the foundation of the Franklin Institute, when the Board of Managers resolved to commemorate the event by holding an exhibition of American manufactures.

Mr. Tatham was largely instrumental in the organization of the Pennsylvania State Weather Service in 1887, in connection with the U. S. Weather Bureau, which lent its active cöoperation to that end. He acted as Chairman of the Committee on Meteorology during the entire period in which the Institute conducted this work, and until the transfer of the Weather Bureau work to the newly-created Department of Agriculture removed the direction of the service from the control of the committee.

Among the papers that he contributed to the Franklin Institute it may be noted that as chairman he was the author of a majority report of the committee on the "Enforced Adoption of the Metric System," in place of our present system of metrology. This report was adverse to its adoption, and is worthy of note as a full yet concise history of the subject, and a valuable contribution to its literature. In its action thereon the Institute committed itself against the enforced adoption of the metric system, but approved the legalized use of it in whatever case or under whatever circumstances it should prove most useful to those who elected to employ it.

Mr. Tatham was elected a member of the American Philosophical Society in April, 1875; he was promptly elected as a Councillor, and in 1897 was made Chairman of the Committee on Finance, and served as Treasurer *pro tem.* upon the decease of the Treasurer, Mr. J. Sergeant Price. He was also a member of the committee appointed to devise a plan for increasing the facilities for the society by enlarging the space to be devoted to the display of its books.

During Mr. Tatham's term as President of the Franklin Institute the dress sword, which was worn by Dr. Franklin upon State occasions, was devised by one of his descendants, Mr. R. Meade Bache, who was then in possession of that historic relic, to the President of the Franklin Institute. This sword had been entrusted to the care of the Historical Society until such time as the Franklin Institute could provide a safe depository for it. This interesting relic is now in the custody of the Institute.

Charles Henry Banes was born in the City of Philadelphia October 24, 1831. He received a public school education and was graduated from the Central High School of Philadelphia in 1847. At the close of his school life he became interested in mercantile pursuits, in which he continued to be engaged until the breaking out of the war of the rebellion in 1861, when he entered the United States Service as Captain of Company E of the 72d Regiment of Pennsylvania Volunteers, continuing in the service until June, 1864. His faithfulness, gallantry and ability in military life are matters of historical record, so that it will only be necessary here to give the following summary. He commanded his company at the siege and capture of Yorktown, in 1862, and in the battle of Fair Oaks, May 31, 1862, Seven Pines, June 1st, 8th and 9th; Garnet Farm, June 15th and 18th; Savage Station, June 28th; Peach Orchard, June 29th; Glendale, June 30th; Malvern Hill,

Charles Henry Banes

July 1st; Chantilly, September 1st; Antietam, September 13th and 17th, and Frederick, December 13th, 1862. On the 26th of December, 1862, having received honorable mention for gallantry in the battle of Fredericksburg, in which engagement he was wounded, he was appointed Assistant Adjutant-General, and confirmed by the Senate May 15th, 1863. He took part in the battles of Chancellorsville, May 12th, 1863; Haymarket, June 24th; Gettysburg, July 2d and 3d, when he was again wounded and honorably mentioned for bravery and gallantry. He was also engaged in the battles of Robertson Tavern, November 26th; Mine Run, December 2d, where again he was honorably mentioned, and in the battle of the Wilderness, May 5th and 7th, 1864; Spottsylvania, May 8th to the 18th; Po River, May 9th; North Anna, May 23d and 27th; Tolopotomy, May 28th; and Cold Harbor, June 1st to the 4th, 1864, where he was so severely wounded as to be incapacitated for further service. He was breveted Major for his gallantry at Gettysburg, and Lieut.-Colonel after the battle of Spottsylvania.

Colonel Banes became a member of the Franklin Institute in October,

1874. He was elected to the Board of Managers of the Institute in January, 1877, and continued a member of this body until 1895, when he declined re-election on account of press of business and ill health. He was President of the Institute during the year 1886. In connection with the work of the Franklin Institute, Colonel Banes is, perhaps, best known on account of the marked ability, the untiring energy, and the rare executive powers which he exhibited at the International Electrical Exhibition, held in Philadelphia in 1884. Considered from the standpoint of the Franklin Institute, this exhibition may justly be regarded as the most important public work the Institute has ever undertaken. Considered from the standpoint of the electrical world, this exhibition has, probably, done more in advancing the cause of electrical science, by placing on public exhibition the products of electricity from different parts of the world, than has any exhibition held prior to 1884. Nor was this due entirely to the exhibits. At the same time, as a natural outgrowth of the exhibition, a National Conference of Elec-

Joseph Miller Wilson

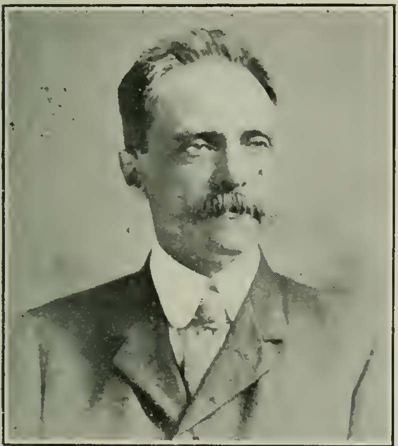
John Birkinbine

tricians was held under the direction of an United States Electrical Commission, created by an Act of Congress, and approved by the President in May, 1884, the Act authorizing the appointment of a scientific commission, "Which may, in the name of the United States Government, conduct a National Conference of Electricians in Philadelphia in the autumn of 1884."

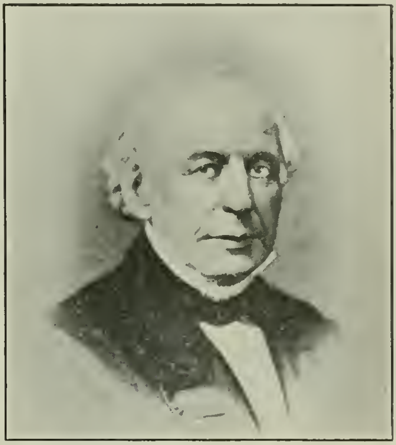
Joseph Miller Wilson was born in Phoenixville, Pa., June 20, 1838; was graduated at the Rensselaer Polytechnic Institute in 1858, and studied Chemistry under Dr. F. A. Genth. He was made Assistant Engineer on the Pennsylvania Railroad in March, 1860, and in 1867 was given charge of all bridges and buildings on the line of that road from New York to Pittsburg and from Canandaigua to Quantico, Virginia. In 1874-6 he was joint engineer with Henry Pettit of the main exhibition building and of Machinery Hall for the Centennial World's Fair at Philadelphia. In January,

1876, with his brothers, he organized the firm of Wilson Bros. & Co. He was President of the Franklin Institute from 1887 to 1897, and President of the Engineer's Club in 1888. He died in Philadelphia November 24, 1902.

John Birkinbine was born in Philadelphia in 1844; studied in the Polytechnic College of Pennsylvania. He served as assistant to his father, who was Chief Engineer of Water Supply for Philadelphia. He was special agent of the 11th and 12th Census. He was President of the American Institute of Mining Engineers 1891-3; President of the Engineer's Club 1893; President of the Franklin Institute 1897 to 1907; President of the Pennsylvania Forestry Association since 1897; Editor of "Iron Workers" for nine years, and is now Editor of "Forest Leaves."



Walton Clark



Matthias William Baldwin

Walton Clark was born April 15, 1856, at Utica, N. Y. He had a common school education. He began work in the New Orleans gas works at the age of seventeen, and has been in the gas, electric light and street railway business ever since. He is Third Vice-President of the United Gas Improvement Company, in charge of the engineering and operating departments. He is a member of the Society of the Cincinnati, the University Club, the Union League, the Racquet Club, and other Philadelphia and New York clubs. He is a member of the American Gas Institute, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Academy of Social and Political Science, and of several State Gas associations. He is ex-President of the American Gas Light Association; ex-President of the American Gas Institute; President of Franklin Institute of Pennsylvania; member of the Board of Trustees of the Chestnut Hill Academy; member of the Board of Trustees of the Pennsylvania Military College; and founder and Chairman of the Board of Trustee of a free correspondence school for gas-works employees. He was awarded the honorary degree of Mechanical Engineer by the Stevens In-

stitute of Technology. He was a member of the Municipal Ownership Commission of the National Civic Federation, and of its organizing and investigating committees, being engaged for nearly two years on the work of this Commission. He lives at Chestnut Hill and has been a resident of Philadelphia for nineteen years.

Matthias William Baldwin was born in Elizabethtown, N. J., December 10, 1795, and at the age of sixteen was apprenticed to a firm of jewelers in Frankford, now Philadelphia. In 1819, he went into business for himself and patented a process for gold plating, since universally adopted. He then commenced the manufacture of book binders' and calico printers' tools for the first time in this country.

In 1828, he built a five horse-power engine which was employed at his own works. In the latter part of 1830 he saw a locomotive which had

Isaac Hays

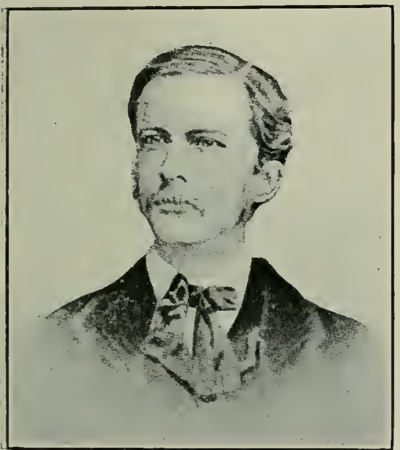
been purchased in England, and after four months' labor he produced a beautiful model of it

The first locomotive he made was for the Philadelphia and Germantown Railway, which commenced service November 23, 1832. During the next three years he received orders for nine or ten locomotives. In 1835 he moved his works to the corner of Broad and Hamilton Streets. His improvements, notably the flexible truck, patented August, 1842, were numerous. His works have acquired a world-wide reputation and have produced not far from a thousand locomotives in a year.

He was a member of the Constitutional Convention of Pennsylvania in 1837, and of the Pennsylvania Legislature in 1853; and was President of the Horticultural Society of Pennsylvania. He died in Philadelphia September 6, 1866.

Isaac Hays was born in Philadelphia July 5th, 1796, and died there April 13th, 1879. He was graduated from the University of Pennsylvania

(Arts) in 1816, and (Medicine) 1820. In 1827 he became Editor of the "Philadelphia Journal of the Medical and Physical Sciences," of which the name was changed to the "American Journal of the Medical Sciences." In 1843 he established the "Medical News," and in 1874 the "Monthly Abstract of Medical Science." He was President of the Academy of Natural Sciences 1865 to 1869. He was one of the founders of the Franklin Institute and for many years its able Secretary. He was distinguished for his learning and high character as well as for his eminent professional attainments. He was one of the founders of the American Medical Association, and the author of its code of ethics, which has been adopted by every State and County Medical Association in the United States.



Henry Morton

William Henry Wahl

Henry Morton was born in New York City December 11, 1836, graduated in the University of Pennsylvania in 1857, and took a post-graduate course in chemistry. He was instructor in chemistry in the Protestant Episcopal Academy of Philadelphia. In 1863 he lectured on chemistry at the Franklin Institute, and assisted in founding the Philadelphia Dental College, of which he became the first professor of chemistry. In the following year (1868) he became Resident Secretary of the Franklin Institute. During the absence of Professor John F. Frazer in Europe, 1867-8, Prof. Morton temporarily took his chair in the University of Pennsylvania, and on Prof. Frazer's return to Philadelphia, Prof. Morton gave instruction in Chemistry during 1869. In 1870, Prof. Morton was made President of the Stevens Institute of Technology, and laid out the courses of instruction in that Institute, presenting it with a work shop costing $10,000, and electrical apparatus costing $2,500. In connection with his photographs of the solar eclipse of 1869 he first established the cause of the bright line in the Sun's disk next to the moon as a local chemical action in the development of the plate. He joined Henry Draper in the latter's private expedition to observe the total eclipse of 1878 at Rawlins, Wyo. In 1873, he made re-

searches into the fluorescent and absorbent spectra of the Uranium salts, of pyrene, and of a substance found by him in petroleum residues and named Thallene. In 1878 he succeeded Prof. Joseph Henry on the Light House Board. He obtained the degree of Ph.D. from Dickinson College in 1869, and from Princeton in 1871. He was elected to the National Academy of Science in 1874. He died May 9, 1902.

William Henry Wahl was born in Philadelphia December 14, 1848, and educated in the public schools and in Dickinson College, from which he graduated in 1867. He pursued special courses in chemistry, geology and mineralogy in the University of Heidelberg, from which he obtained the degree of Ph.D. in 1869. He was instructor in Science at the Protestant Episcopal Academy 1871-3, Professor of Physics and Physical Geography in the Philadelphia Central High School 1873-4, Editor of the "Polytechnic Review" 1876-8; Associate Editor of the "Engineering and Mining Journal" 1878-80; Editor of the "Manufacturer and Builder" 1880-95, and Resident Secretary of the Franklin Institute 1870-74, and from 1882 to the present date.

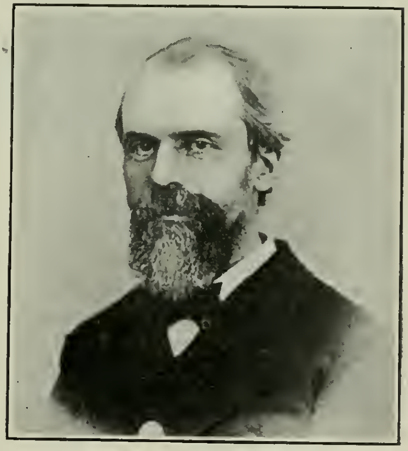
Jacob Brown Knight

Jacob Brown Knight was born near Brownsville, Jefferson County, N. Y., June 2, 1833. His ancestors, Giles and Mary Knight, were members of the Society of Friends, and came to America with William Penn, in the ship "Welcome," in the year 1682. They settled in Byberry, Philadelphia County, Pa., where their descendants are numerous. The subject of this memoir was named after an uncle of his mother, Major-General Brown, a distinguished officer of the war of 1812. He received his early education at the Watertown Institute, and in his youth exhibited a taste for mechanical pursuits. He afterwards received a practical training in the machine works of Hoard & Sons, Watertown, and in those of Merrick & Sons, in this city. His health failing, in 1855 he went to the South and was en-

gaged in the erection of sugar and cotton machinery, when the breaking out of the rebellion proved disastrous to his fortunes. He then became a consulting engineer in the City of New Orleans, and was an officer of a society of engineers established there, and was an occasional contributor to DeBow's Review. Mr. Knight was elected a member of the Franklin Institute September 13, 1873, and evinced his interest in this body by occasional gratuitous services. In April, 1874, as a member, he volunteered his assistance in the preparations for the Exhibition to take place in the ensuing fall. In this position his assiduity, good judgment, zeal, intelligence and good address, pointed him out as a suitable person for the position of General Superintendent, and to this position he was appointed by the Chairman of the Committee on Exhibitions, upon the first of July, 1874. Subsequently he was appointed Secretary *pro tempore* of the Institute, and was elected to that office at the annual election in January, 1875. He was continued in the office by successive re-elections, and exercised the functions until about ten days before his death, which occurred March 10, 1879.

At the time of his death, Mr. Knight was Secretary of the Franklin Institute, Editor of the *Journal* of the Institute, Representative of the Institute in the Board of Trustees of the Pennsylvania Museum and School of Industrial Art, Vice-President of the Young Engineers' Club, and Member of the American Philosophical Society.

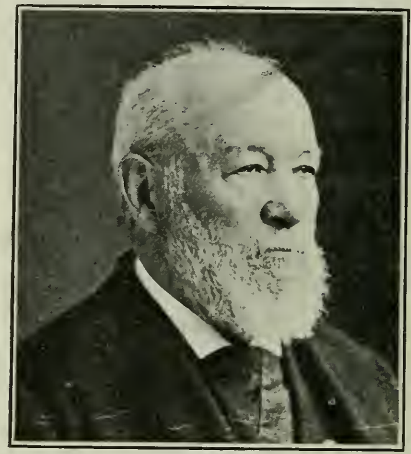
Isaac Norris



Samuel Sartain

Isaac Norris was born in Philadelphia June 12, 1834, graduated from the University of Pennsylvania (Arts) in 1852, and from the Medical College in 1855. He was acting Assistant Surgeon U. S. A. from 1862 to 1865; Professor of Chemistry at the Philadelphia Central High School 1866 to 1876; Physician at the Philadelphia Dispensary 1865 to 1867; Secretary of the Franklin Institute 1878 to 1881, and Secretary of the College of Physicians 1885.

Samuel Sartain, son of John Sartain, was born in Philadelphia October 8, 1830. At the age of sixteen years he began to engrave under his father's instruction, but after his twenty-first year was in business for himself. His prints include "Clear the Track!" after Schuessele, "Christ Blessing Little Children," after Sir Charles L. Eastlake (1861), &c. He has devoted his energies principally to designing, portraits and other plates for books. He held offices in the Artists' Fund Society, in the Franklin Institute, of which he was Treasurer from 1883 to 1907, and in other Societies. He died December 20, 1906.



David Shepherd Holman

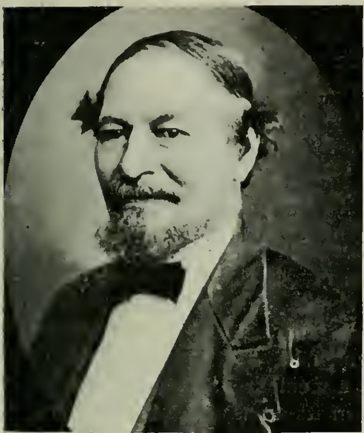
David Shepherd Holman, who was Actuary to the Franklin Institute from 1871 to 1885, died at Bangor, Maine, on May 13, 1901.

Mr. Holman was born in Milo, Maine, in 1826, and at the time of his death was in his seventy-fifth year. He became identified with the Institute as a member in 1866, and at once took an active interest in its work. Although he was to a great extent self-educated, and had not enjoyed the advantages of early scientific training, he succeeded in becoming a skillful microscopist, and, being gifted with great mechanical ingenuity, devised a number of useful microscopic accessories, with some of which his name is associated. Of these, perhaps, the best known are the so-called "Holman life-slides," which he devised for the purpose of facilitating the study of the vital functions in living animals. He also originated other devices and methods for illustrating the circulation of the vital fluids in animals and plants, which gained for him considerable local repute.

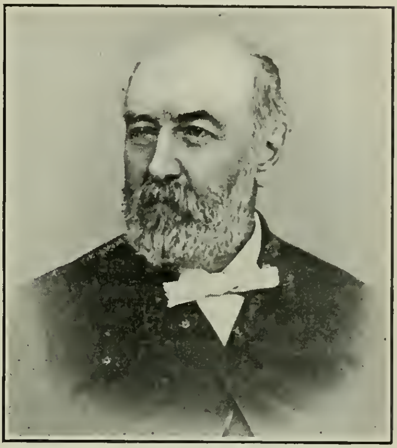
He was mainly instrumental in the foundation of the Optical Section of the Franklin Institute, in the year 1872, the first Section to be founded in the Institute.

Mr. Holman was among the first to foresee and appreciate at their true value the great advantages of the typewriting machine at the time of its

first introduction, and when the future of this great time- and labor-saving device was still problematical. From the beginning, his faith in the universal applicability of the typewriter, with the supplementary aid of stenography, was unbounded. He gave practical form to his ideas on this subject by founding, in 1873, at the Institute, a school of stenography and typewriting, which soon was largely attended and most successful. All this seems but a commonplace matter from the point of view of to-day, but the local stimulus that Mr. Holman's pioneer work gave to the modern art of correspondence was unquestionably of great value, and he is entitled to the fullest recognition for this service.



John Sartain



Frederick Graff

John Sartain was born in London October 24, 1808, where he learned line engraving. In 1828 he began to practice mezzo-tints, introducing that art into the United States, to which he came in 1830. In 1843 he became proprietor and editor of Campbell's Foreign Semi-monthly Magazine, and thereafter devoted himself to engraving and to literary work. In 1848 he purchased a half interest in the "Union Magazine" of New York, which he transferred to Philadelphia, changing its name to "Sartain's Union Magazine." The framing prints from his studio include "Christ Rejected," after Benjamin West; "The Iron Worker and King Solomon" (1876); "John Knox and Mary Queen of Scots," after Leutze; "Edwin Forrest," "The Battle of Gettysburg," after Rothermel, &c. He held various offices in the Artists' Fund Society, the School of Design for Women, and the Pennsylvania Academy of Fine Arts. He was in charge of the Art Department at the Philadelphia Centennial World's Fair. He designed the monument to Washington and Lafayette in Monument Cemetery, Philadelphia. He died October 24, 1897.

Frederick Graff, Civil Engineer, was born in Philadelphia May 23d, 1817, son of Frederick-Judith (Swyer) Graff. His great-grandfather, Jacob

Graff, came from Germany to Philadelphia in 1741; his grandfather, Jacob Graff, 2d, was a builder, and his father (1774-1847) designed and constructed the water-works of Philadelphia, and was its chief engineer until his death. It was his wish that his son should engage in mercantile pursuits; but a short experience in a large hardware house satisfied the young man that this occupation was not congenial, and entering on the study of engineering, he, on April 6th, 1842, became an assistant engineer on the Philadelphia water-works. On his father's death, in 1847, made chief engineer, and held that position until 1856. He was again elected to the office in 1866, and served for six years, after which he declined re-election. He was the Manager of the Port Richmond Iron Works of Philadelphia (1860-63); associated with H. R. Worthington in the development of pumping machinery for water-works (1873-77); and during the next ten years was frequently called on as an expert in engineering matters connected with the water supply of cities, especially as regarded pumping machinery. In March, 1873, he became a member of the American Society of Civil Engineers, and was President of the Society in 1885. He visited Europe twice, making on the second occasion, in 1878, quite an extended tour. The record of Mr. Graff's professional career, embracing as it did the entire reconstruction and enlargement of the water-works of Philadelphia, which in its day was one of the great engineering works of the country, covers but a small portion of the services he rendered his native city. In 1851 he presented to the city government the suggestion of establishing a park upon the banks of the Schuylkill, which resulted in the development of the great Fairmount Park system, in which he was actively engaged as one of the Park Commissioners. He was a member of the Franklin Institute from 1839 until his death, being one of its managers for six years, and Vice-President for three years; was one of the founders of the Zoölogical Society and Gardens of Philadelphia, and after 1882 was its President; was President of the Engineers' Club of Philadelphia in 1880, and was for six years President of the Photographic Society, of which he was one of the founders. As a devout adherent of the Protestant Episcopal Church and an earnest worker, many important interests both religious and civil were entrusted to his management. Mr. Graff was married to Elizabeth, daughter of Captain John Mathieu, of Philadelphia, who survived him. He died in Philadelphia, Pa., March 30, 1890.

Charles Bullock, 6th President of the Philadelphia College of Pharmacy, from 1885 to date (1891), was born in Wilmington, Del., in 1826, a descendant of a prominent family of Friends, whose ancestors were early settlers in New Jersey. His father, the principal of a boarding school for boys in Wilmington, was widely known as one of the most popular and successful educators of his time. After receiving a thorough training in his father's school, he completed his education at Haverford College, near Philadelphia. Early in his career he evinced a special taste for the study of the natural sciences. The fondness was further stimulated and developed by frequent intercourse with his uncle, John Griscom, LL.D., of New York City, one of the first persons in America to introduce into schools

systematic instructions in chemistry. After leaving college, Mr. Bullock entered the employ of Smith & Hodgson, Sixth and Arch Streets, Philadelphia, the senior member of the firm being Daniel B. Smith, who for many years was President of the College of Pharmacy and a member of the Faculty of Haverford College. In this store he acquired a knowledge of the business, and was graduated from the College of Pharmacy in 1847. Soon afterward, in connection with E. A. Crenshaw, he succeeded to the business of his employers, and the firm of Bullock & Crenshaw was formed and entered upon its prosperous career. They made a specialty of furnishing physicians with their outfits, and pharmacists with their drugs and chemicals, and the firm soon became favorably known throughout the country for the excellence and superior character of their supplies. Mr. Bullock developed an increased interest in chemistry, and in 1851 visited

Charles Bullock

Robert Henry Thurston

the large cities of Europe on a tour of investigation for better information regarding the importation of chemicals and chemical apparatus for scientific use. The firm has since made this an important part of their business. His fondness for chemical research induced him to engage in preparing chemicals for experimental and analytical purposes, and in this department the firm of Bullock & Crenshaw has long been recognized as foremost in the country. Mr. Bullock began his contributions to the literature of chemistry and pharmacy in 1848, by an article on "Kalmia Latifolia" in "The American Journal of Pharmacy." Since then fifty or more valuable contributions from his pen, showing investigation and research in his chosen field of science, have appeared in the same journal and in the Proceedings of the Pharmaceutical Association, of which he has long been a member, and was its Vice-President in 1876. He has published an exhaustive article on "Akaloids of Veratrum Viride," which attracted considerable attention among investigators of medicinal plants. Mr. Bullock

has always taken a deep interest in the welfare of the College of Pharmacy. He served a long time as Secretary and Vice-President in succession, and since 1885 has been President of the College. He is Vice-President of the Franklin Institute and a member of the American Philosophical Society and of the Academy of Natural Sciences of Philadelphia. He was for many years a vestryman of the historic Christ's Episcopal Church, of Philadelphia, and is now a vestryman of St. Peter's Church, Germantown.

Henry Christopher McCook

Harvey Washington Wiley

Henry Christopher McCook was born in New Lisbon, Ohio, July 3, 1837. After learning the printer's trade and teaching for several years, he was graduated at Jefferson College, Pennsylvania, in 1859. He studied Theology privately and in the Western Theological Seminary at Allegheny, Pennsylvania, and after serving for nine months as First Lieutenant and Chaplain in the army, had pastorates at Clinton, Illinois, and St. Louis, Missouri. In 1869 he became pastor of the Seventh Presbyterian Church in Philadelphia, now known as Tabernacle Presbyterian Church. He has published valuable papers on the habits of American ants and spiders, is Vice-President of the American Entomological Society, and of the Academy of Natural Sciences, Philadelphia. The degree of D.D. was conferred upon him by Lafayette College in 1880.

Harvey Washington Wiley was born in Kent, Indiana, October 18, 1844; graduated at Hanover College in 1867; and at Harvard in 1873. He was Professor of Chemistry at Purdue University 1874-83; State Chemist of Indiana 1881-3; Professor of Agricultural Chemistry in the graduate school Columbian University since 1895; delegate from the United States to the Fourth International Congress of Applied Chemistry, Paris, 1900; Chief of the Bureau of Chemistry in the Department of Agriculture from 1883 to the present date, and is Professor of Agricultural and Hygienic Chemistry in the Franklin Institute.

The complete list of private benefactions and endowments to the Franklin Institute here follows:

James Ronaldson, first President	$ 500.00
A. Miller, a legacy	1819.77
Algernon S. Roberts, for the purchase of books	800.00
Branabas H. Bartol, for the endowment of a scholarship in the drawing school	1000.00
For the building fund	500.00
Elliott Cresson, for his Gold Medal	1000.00
Henry Seybert, for purchase of books, $500; for building fund, $2000.	2500.00
Uriah A. Boyden, for solution of a problem in light (lately awarded and paid to Paul R. Heyl)	1000.00
John Lenthall, his library	———
Joseph Newmann, residuary interest in his estate	(not yet paid)
John Turner, the income of (about)	1000.00
Mrs. W. B. Rogers, chemical library of Robt. E. Rogers	———
Edward Longstreth, for his Silver Medal	1000.00
Geo. S. Pepper, in all to date (endowment fund)	34437.50
Mrs. Fred'k Graff, valuable drawings and engravings	———
Eugene Nugent, legacy to endowment fund	1000.00
	$51,157.27

In all $51,157.27, of which $12.400 is for specific purposes and only $38,757.27 is available as an unconditional endowment which represents an income of less than $2000. To this should be added occasional gifts, amounting perhaps to $20,000, which generous members, especially among the managers and officers, have from time to time given unconditionally to meet some emergency which was pressing.

The average annual cost of running the Institute in late years has been about $20,000, of which less than one-tenth is covered by its income; the remainder from members' dues, the profits of the *Journal*, and irregular contributions of the members and a few among the public, aided too frequently by funds extracted from the Institute's accumulated profits, principally from the Exhibition of 1874, which are now pretty well exhausted.

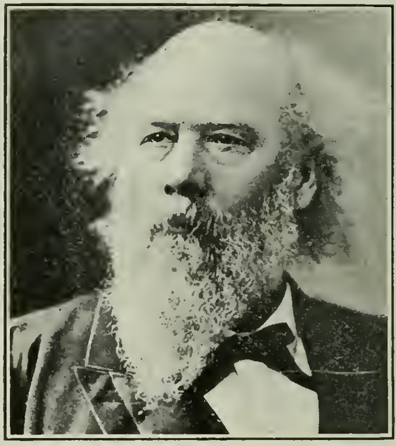
Neither the Federal Government, the Commonwealth, nor the municipality has ever contributed one cent to support the Institute; monies or instruments having been given to it only when special labors from which the givers would benefit have been required and received in return.

SERVICES.

Among the services rendered to mankind by the Franklin Institute may be reckoned the institutions which have budded from it.

It is not too much to claim our Philadelphia High School as an off-shoot from the Franklin Institute, which abandoned its own high school when the standard of public education was raised in this city in the early thirties of the last century.

The School of Design for Women was founded by the Franklin Institute in 1850, and has ever since maintained its reputation as one of the greatest of benefactions.



George Wallace Melville

George Wallace Melville was born in New York January 10, 1841; educated at the public schools and at the Brooklyn Polytechnic Institute; appointed to the U. S. Navy as Assistant Engineer July, 1861, and served with distinction through the civil war, and later at various U. S. Navy stations. In 1879 he sailed with DeLong in the Jeannette for the Arctic, and commanded the boat which escaped from the wilds of the Lena Delta. Subsequently he commanded the expedition which recovered the records of the Jeannette expedition and the remains of DeLong. He was awarded by Congress a gold medal, and advanced fifteen numbers for bravery in the Arctic. He was appointed in 1887 and re-appointed in 1892 and 1896 Engineer-in-Chief of the U. S. Navy, and was promoted to the grade of Rear Admiral in 1899. He retired in 1903. He was the designer of the triple screw machinery in the Columbia and the Minneapolis. He was President of the American Society of Mechanical Engineers.

The Pennsylvania Museum and School of Industrial Art, while called into existence by the great Centennial Exposition, was housed and fostered by the Franklin Institute in its early years.

The University Museum is the heir of the project of the Franklin Institute for an Art School in 1837, which failed of an appropriation by the Legislature, though the City Councils granted the plot of ground.

The Institute of Electrical Engineers is a direct result of the Electrical Exhibition of the Franklin Institute in 1884.

Some of the many institutions which have availed themselves of the experience and methods of the Franklin Institute in their organizations are: The Maryland Mechanics' Institute; the American Institute of New York; the Ohio Institute of Cincinnati; the San Francisco Institute; the Pratt Institute, of Brooklyn; the Lowell Institute, of Boston; the Armour Institute, of Chicago; and the Cooper Institute, of New York. These are only a few of the many which have adopted the lines of activity exploited and proven by the Franklin Institute.

An attempt has been made to ascertain the number of those who have profited by the instruction in the schools of the Franklin Institute. For the earlier years up to 1881 only approximations could be obtained, but from 1881 to 1908 the numbers given are from actual count:

1824-1831	350
1831-1841	500
1841-1851	900
1851-1861	1000
1861-1871	1500
1871-1881	1680
1881-1890	3273
1890-1899	2615
1899-1908	2764
Total, 1824 to 1908 (84 years)	14,582

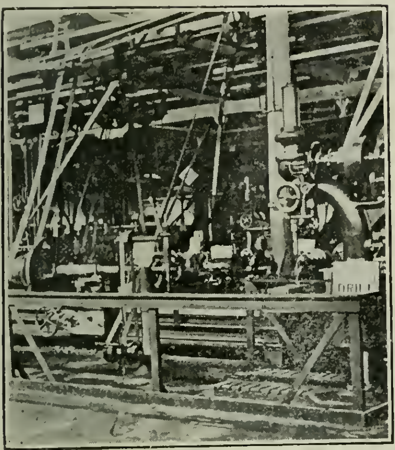
This means that an average of 173 men, both young and mature, have been annually helped on their journey to usefulness and self-support by this Institute. If you would know what places these products of our educational machinery have filled in the world, two names from the earlier years suggest themselves: Thomas U. Walter, a young bricklayer, who was one of the first to avail himself of the advantages of the instruction given here,

became an architect of national reputation, and later Professor of Architecture in the Institute's faculty in 1842, enduring monuments of whose skill may be seen to-day in Girard College and the National Capitol at Washington. One of the most distinguished men who has ever filled the Presidential chair of the Institute, whose death we have lately been called upon to mourn, Dr. Coleman Sellers, received a part of his primary education within these walls.

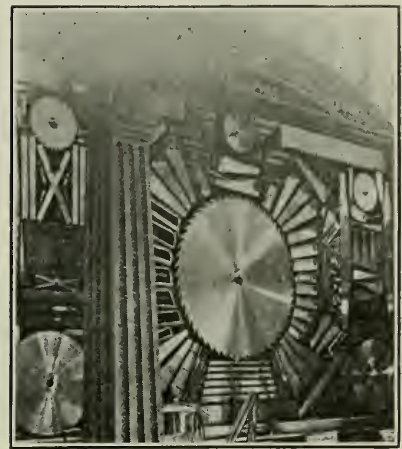
For the rest, a visit to any of the great work shops of the country will be likely to reveal one or more among the bosses or officers who thanks the schools of the Franklin Institute for his early training.

The Exhibitions of the Institute have been of the greatest value to the City, State, and Country, as witness the testimony of the Board of Managers in 1838, before quoted, where it is intimated the rapid progress of the Arts throughout the country between 1824 and that date was partly due to the ambition of manufacturers to surpass their rivals at the Franklin Institute's annual competitions. Within eight months of the foundation of the Franklin Institute a successful exhibition under its auspices was held in Carpenters' Hall.

The earliest exhibitions of this Institute (and certainly some of those in the fifties of the last century which your speaker remembers) were held in the Masonic Temple, in Chestnut Street above Seventh, on the north side. Dr. Wahl tells us in his interesting history written in 1894, that some intermediate exhibitions were given yearly or every other year at the Chinese Museum, Ninth and Sansom Streets, or until that structure was burned, in 1850. They were discontinued from 1858 till after the war, and the first great exhibition mentioned by the authority just quoted was in the year 1874, when the Pennsylvania Railroad had sold to John Wanamaker the site of his present enormous granite structure, then a freight depot. Through the foresight and activity of Messrs. Wm. P. Tatham and Charles H. Banes, this depot was secured for the exhibition. The great Central Sanitary Fair held in Logan Square ten years before, during the progress of the Civil War, which netted the army and navy hospitals over a million dollars, had opened the eyes of our people to the possibilities of a worthy exposition, and the Franklin Institute Exhibition of 1874 profited by the experience, indeed was aided by many

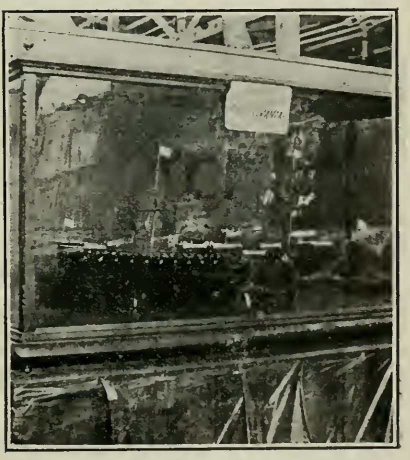


Franklin Institute exhibition of 1874
Bement & Dougherty



Franklin Institute exhibition of 1874
Disston's exhibit

Franklin Institute exhibition of 1874
Carriages



Franklin Institute exhibition of 1874
S. S. Pennsylvania (American Line)

who had made the Sanitary Fair a success. It ranks to-day as the most successful exhibition of its kind which was ever held, up to that time. As the result of a resolution of a meeting of the Franklin Institute in August, 1869, and addressed to the Councils of the City of Philadelphia, suggesting an exhibition of the whole people of the United States to commemorate the completion of the hundredth year of our independence, a great Centennial Exposition had been undertaken, preparations for it were well advanced and it was but two years off. The exhibition of 1874 by the Franklin Institute served as a practice canter to try the condi-

Exhibition building, Franklin Institute, 1884

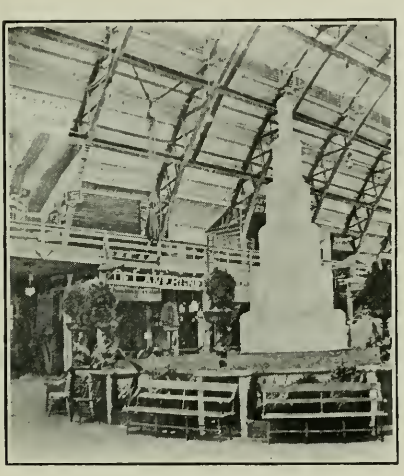
tion of the people of Philadelphia. The results of this effort were splendid for the community and for the Institute. Dr. Coleman Sellers, who made the address at the closing ceremonies, and Mr. Tatham, who made the report, have ably summed up the results, and a relic of our shout of triumph remains in an old lantern slide now thrown on the screen. This exhibition was a God-send to the Institute. From its $52,000 net profit of stored-up energy we have been drawing, in our moments of necessity, ever since, until there is very little kinetic force left.

In 1884 the greatest electrical exhibition ever till that time held in the United States, was added as an additional diadem in the Institute's crown of glory. It was international in character, but like our great Centennial Exhibition to which alone among the general exhibitions called national or international ever held in this country, the Federal Government refused to contribute a dollar, it was obliged to seek its support from private contributions.

The result was that while it was a magnificent success, both from a scientific and a financial point of view, all the profits which would otherwise have justly benefitted the Institute were disbursed for the cost of equipments, buildings, and installations. A few thousand dollars remained after these expenses were paid.

The Novelties Exhibition which followed the next year was not a success from any point of view.

Among the chief services rendered to the nation, State and city by the Franklin Institute is that of furnishing through the unpaid labors and unswayed judgment of its Committee on Science and the Arts a rod of menace to the wrong-doer and a shield of pro-

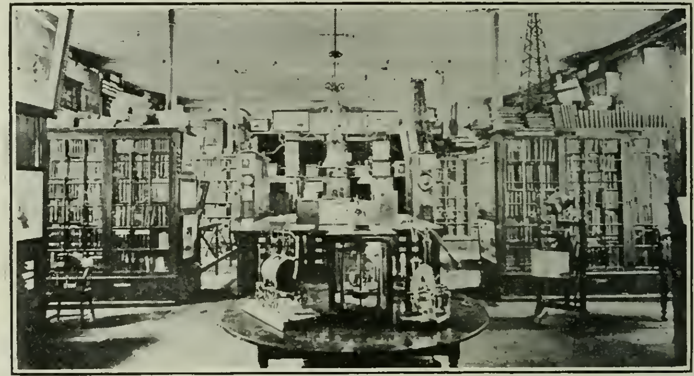


Franklin Institute exhibition of 1885
Frozen fountain

tection to the government and citizen. Whenever the State or city administration has asked the Institute's aid in sifting a technical statement, or ascertaining whether a product was up to specifications, this information has been cheerfully, promptly and ably given, and with such authority that no appeal from the decision has ever yet been sought elsewhere. The Franklin Institute thus has contributed to the tax-payer a mighty private watchman of whom his enemies stand in awe.

Hardly less in value, though of a very different kind, is the aid which the Franklin Institute renders again through its great committee,—by the award of prizes to those who have really enriched their fellow beings by inventions and discoveries.

John Scott, of Edinburgh, by his will of date 1816 bequeathed $4000 to the corporation of the City of Philadelphia, directing the interest and dividend should be laid out in premiums to be distributed, each with a copper medal bearing the inscription "To the Most Deserving," to ingenious men and women who make useful inventions. The Councils of this City by ordinance of February 27, 1834, vested the duty of selection and award in the Franklin Institute. On the creation of a Board of Directors of City Trusts by the Legislature of Pennsylvania in 1869 this passed into their hands, and they by resolution in 1882, referred it to their sub-committee on Wills Hospital and Minor Trusts. This committee placed the selection again in the hands of the Franklin Institute for report to them, and the Franklin Institute delegated this duty to its Committee on Science and the Arts. No proposal of a candidate by this committee has ever been rejected by the Institute or by the Board of City Trusts.



Franklin Institute. Interior of library, 1874 to 1898

Elliott Cresson, of Philadelphia, February 18th, 1848, conveyed $1000 in securities to the Franklin Institute to pay for suitable dies and for the preparation of gold medals to be awarded by it to such persons as it may designate who have either made discoveries in the Arts and Sciences, or inventions or improvements of useful machines, or some new process or combination of materials in manufacture, or for ingenuity, skill, or perfection in workmanship. This award was also referred to the Committee on Science and the Arts, under the same conditions which govern its proposals for the John Scott legacy premiums.

March 23, 1859. Uriah A. Boyden deposited with the Franklin Institute the sum of $1000, to be awarded as a premium to any resident of North America who shall determine by experiment whether all rays of light and other physical rays are or are not transmitted with the same velocity. The problem was more specifically defined by the Board of Managers whether or not all rays in the spectrum known at the time the offer was made (March 23, 1859), *i. e.*, between the approximate frequencies of 2×10^{14} and 8×10^{14}, travel through free space with the same velocity. This prize was won by Dr. Paul R. Heyl, Professor of Physics in the Central High School of Philadelphia, and awarded

Franklin Institute library book stack, 1898

to him by resolution of the Board of Managers of the Franklin Institute dated June 19, 1907.

In 1882, the Franklin Institute authorized the Committee on Science and the Arts to award certificates of merit to persons judged worthy by reason of inventions, discoveries, or productions.

In 1890, Edward Longstreth, machinist in the Baldwin Locomotive Works, transferred to the Franklin Institute securities of the value of $1000, the interest of which is to be expended for silver medals to be awarded by the Committee on Science and the Arts for the encouragement of invention and in recognition of meritorious work in Science and the Industrial Arts.

The honor of possessing these tokens of achievement without

doubt has been a strong incentive to useful research, and the cause of many notable and useful discoveries and inventions.

The reports of the Franklin Institute's special committee on the economic utilization of water power; on the explosion of steam boilers: on the strength of materials; on the reforms desirable in our system of weights and measures; on the weather through a corps of trained observers (which led the way to the present national weather bureau); on uniformity of screw-threads (which was not only generally adopted by manufacturers and by the United States Government, but was practically copied by the German Empire in 1887, though adapted to the metric system); on the water supply of Philadelphia; on the efficiency of dynamo-electric machines for arc lighting in 1878; on the life, duration

Franklin Institute facade 1890

and efficiency of incandescent lamps in 1884 (the parts of which relating to the wiring of buildings have since been embodied in the regulations of the Fire Underwriters' Association). All these reports now belong to the classics of the subjects of which they treat and have added immensely to the influence of the Franklin Institute, and to the fame of our city.

Without derogation to the work of our sisters, the American Philosophical Society (under whose auspices Rittenhouse did actually observe the transit of Venus in the 18th Century), and the Academy of Natural Sciences, whose contributions to the needs of humanity consist mainly in discoveries of hitherto un-

known facts and laws of nature, regarding which our name-saint, Benjamin Franklin, when asked their value, pithily said, "What is the value of a newly-born babe?" none of them has compared with the Franklin Institute in gifts of immediate value to mankind; yet both have been aided by large donations from the National, State, or City governments, while the Franklin Institute has never received a cent except for value rendered.

DESERTS.

The list of services of the Institute might be extended very largely, but it is enough to establish the fact that men of the greatest eminence cöoperated at the inception, and during the early history of the Institute, in laying deep and broad the foundations of her usefulness—men who gave the labor of years unrecompensed except by the appreciation of people of the highest culture—chiefly outside of Philadelphia and Pennsylvania.

In justice to these men and their unselfish work the people of this State should not allow this unselfishness to diminish or the Institute's influence to decline.

It was recognized as long ago as the thirtieth decade of the last century that the building, then not twenty years old, and the location of the Institute, were inadequate to her needs.

The disastrous crash of 1837 fell with peculiar severity upon her, and her loss of money at that time has had a deterrent effect upon all efforts to better her position since. From time to time committees to solicit a building fund were appointed, and during the presidency of Mr. Joseph M. Wilson twenty odd thousand dollars were collected, paid and deposited to the credit of the Institute.

Finally a new hope arose that the fund laid aside by the great Philosopher-printer might be used to establish an institution which would have been dearer to his heart than any scheme of bringing Wissahickon water to the City Hall, or paving the streets.

In February, 1906, it was ascertained that although in the previous year the increased principal of the Franklin fund, less the £1000 set apart by the will, had been awarded by the Board of Wills Hospital and Minor Trusts to a body of citizens for the erection of an Art gallery, yet no steps had in the meantime been

taken to erect such a gallery, and the conditions of the gift being unfulfilled the appropriation was null and void.

A committee was appointed to solicit contributions for a new building. Mr. Alfred C. Harrison was a member of this committee, and in addition to his generous acts in connection with this and many other charitable institutions, for which he will always be gratefully remembered by Philadelphians, he headed the list with a subscription of $50,000, to which the Baldwin Locomotive Works added $25,000.

In a short time $100,000 was subscribed.

The City of Boston had managed the like sum of £1000 which Franklin had left to its care so much more successfully than the City of Philadelphia that it had grown to $418,000 in contrast with $125,000 here. The City of Boston determined to apply it to the erection of such an institute as ours, and to this end donated

Proposed site and supposed view of the projected new Franklin Institute looking from City Hall

a plot of ground worth $100,000. Mr. Andrew Carnegie, the greatest and wisest giver in all history, gave an amount equal to that derived from the Franklin bequest toward this end, making the fund $836,000, or with the City of Boston's contribution $936,000—close to a million dollars.

The Franklin Institute committee proposed to the Board of Trustees to transfer to the City of Philadelphia a plot of ground secured for the Franklin Institute at the corner of Sixteenth and Arch Streets, and to add the sum of $100,000 to be paid to the city on condition that the city would become Trustee of the Building Fund, holding the building when erected exclusively for the uses of the Franklin Institute; and further, that the city would add the Franklin fund of $125,000 to the Institute's contribution of $100,000 for the purpose of erecting the building. This offer was accepted April 16, 1907. While the ability of the Franklin

Institute to raise the necessary amount of money agreed upon was still in doubt, Mrs. Anna W. Walker generously and most opportunely gave the princely subscription of $50,000 in memory of her father, Mr. Weightman, thus clinching the proposition and assuring the Institute a new lease of life under greatly improved conditions.

The amount now in hand is as follows:

Franklin Fund, from the City of Philadelphia	$125,000
Old Building Fund	20,000
Subscriptions to date*	193,455
	$338,455
Add the value of the present building (say)	60,665
Total in round numbers	$400,000

Proposed new building of the Franklin Institute, 16th and Arch streets, Philadelphia

At least $200,000 more is needed to provide a suitable building as a memorial to Benjamin Franklin, and the (Benjamin) Franklin Institute, and an additional sum to furnish an endowment for maintenance.

The general plan is to erect a four-story building with high basement, which latter is to contain the laboratories and an exhibition hall, seating about 500 people. The second floor will contain the balcony of the auditorium and the committee rooms, Secretary's room, and a museum showing the developments of the

*Now over $200,000.

arts. The fourth floor is for the library, in which it is proposed to use the combined alcove and stack system.

If the building be erected at Sixteenth and Arch Streets the auditorium entrance will be on Sixteenth Street and the main entrance on the new Boulevard.

Ladies and Gentlemen, it is St. Valentine's night. You know St. Valentine was a Bishop and martyr put to death in Rome on February 14th, 270, by Claudius II. (or some say Aurelian) for opposing the Organization of his time.

The custom of choosing Valentines is very old. On St. Valentine's Eve (but evening will do as well) each person present put a slip of paper bearing his name into a box. Then each man drew a slip from the box containing the names of the women, and he was the true Valentine for a year of the lady whose name he drew.

Let us renew the custom, with the modifications which the eighteen centuries of advancing civilization suggest. Let each of you write his name on a slip of paper, preferably a bank cheque, with a good round sum written above it. And the Actuary will draw out of his book (which is the modern substitute for a box) a slip for each with the name of the Franklin Institute written on it in acknowledgment. So shall the Franklin Institute be the Valentine of you all for not only one, but for many a year; and so shall we preserve, with improvements, the custom handed down to us across the vast vista of centuries.

The Editors of the Journal feel called upon to supplement Dr. Frazer's notices of men whose work in connection with the Franklin Institute has most notably contributed to the extension of its activities by due reference to his own collaboration in that regard and to his life work generally.

Persifor Frazer, geologist and chemist, was born in Philadelphia, July 24, 1844. He was graduated from the University of Pennsylvania in 1862; was aide in U. S. Coast Survey and served in South Atlantic Squadron in 1862-3; volunteered with the Phila-

delphia City Troop in the Gettysburg Campaign in 1863, and thereafter served as acting ensign in the Navy until the close of the war, in 1865. He studied at the School of Mines, Freiberg, Saxony, 1868-69; was Mineralogist and Metallurgist in the U. S. Geological Survey 1869-70; Professor of Chemistry, University of Pennsylvania, 1870-4; assistant in the second Geological Survey of Pennsylvania, 1874-82, and was accorded the degree of Doctor in Natural Science by the University of France. He became Professor of Chemistry at the Franklin Institute, and an editor of its journal, 1882-1894, resuming since 1903; Professor of Chemistry at the Horticultural Society of Pennsylvania since

Persifor Frazer

1889. Dr. Frazer is author of Tables for the Determination of Minerals; Bibliotics, or the Study of Documents; four volumes of the Reports of the Second Geological Survey of Pennsylvania; Life and Letters of E. D. Cope; Matriculate Catalogue of the University of Pennsylvania (in collaboration); and volumes I and II of "Descendants of Persifor Frazer;" also 300 papers and contributions published by scientific societies. He is a life member of the American Philosophical Society, Academy of Natural Sciences, Historical Society of Pennsylvania, American Institute of Mining Engineers (of which he is Vice-President); Pennsylvania Horticultural Society, British Association for the Advancement of Science, Sociedad Cientifica Antonio Alzate of

Mexico, Société Géologique du Nord, France, Société Géologique de Belgique, Belgium, Military Order of the Loyal Legion of the United States Naval Veteran Association; Cincinnati Society in New Jersey; Pennsylvania Society of the Sons of the Revolution; member and Vice-President of the Society of the War of 1812; member of the Society of Colonial Wars in Pennsylvania, Society of American Authors; life fellow of the American Association for the Advancement of Science, and Geological Society of America. Officier de l'Instruction Publique, France; and correspondent der Reichsanstalt of Austria. He received from the City of Philadelphia on recommendation of the Franklin Institute, the John Scott Legacy Medal for a colorimeter in 1906. He is a member of the Board of Managers of the Franklin Institute.

LIQUID AIR AS AN EXPLOSIVE.

A few notes on the use of liquid air as an explosive are given in the *Montan-Zeitung* (May 15, 1907). The substance was first used only in combination with others. It is now used alone, its explosive power depending upon its property of turning suddenly into vapor at an elevated temperature. If the vessel in which the liquid air is contained is sufficiently tight, very high expansive powers are attained. For this reason it is stored in vessels having a small opening. This property of the liquid air makes it necessary to place the cartridge in place in the rock before it is loaded. In English mines the cartridges are made of thick phosphor-bronze, the loading being calculated so that the pressure reaches 5.6 kg. per sq.cm. The explosion takes place in six or eight minutes after loading and about thirty tons of coal are broken by one shot. The coal falls in blocks about 60 cm. in circumference. A heavier loading of the cartridge causes the coal to be broken into powder.—*Eng. and Min. Jour.*

SULPHURIC ACID MANUFACTURE IN GREAT BRITAIN.

In Great Britain sulphuric acid is made almost entirely from pyrites, imported chiefly from Spain. Brimstone is used less every year, and is reserved for the manufacture of acid for very special purposes. Sulpheretted hydrogen derived from the waste gases of sulphate of ammonia manufacture has been applied extensively during recent years and is an important source of supply of sulphur. British producers of sulphuric acid complain of the increasing difficulty of obtaining pyrites free from or low in arsenic, and several new plants for de-arsenication have had to be erected. The process now used by the United Alkali Company for removing arsenic produces it as pure arsenious acid, instead of the mixed mud of arsenious sulphide as formerly. It is interesting to note that in the midland counties of England "coal brasses" from the coal mines are used as a source of sulphur at the sulphuric acid works.—*Eng. and Min. Jour.*

Appliances for Manipulating Lifeboats on Sea-Going Vessels.

By Axel Welin, A. I. N. E.

Mechanical Engineer, London.

Few contrivances in general use on land or sea have been subjected to so numerous and so determined attacks by the inventor as the familiar round bar boat davit. The primitive simplicity and consequent cheapness of this device, coupled with the great, though not very apparent, difficulty of designing something really superior, have stood it in good stead. While in almost every other respect mail steamers of half a century ago must look with astonishment on the present-day "greyhound," in this one detail are the two creations alike. And yet, I have hardly met a single man, sailor, engineer or naval architect, among the hundreds with whom I have discussed the subject, who did not maintain that improvements were not only desirable, but, in fact, necessary. Seafaring men are, I believe, rightly looked upon as being particularly conservative, and the fact, therefore, that the great majority of patents for mechanical davits have been applied for by members of that profession is significant.

The last time I had an opportunity of watching regulation boat drill on a large liner the conditions were the most favorable—broad daylight, no wind, and the ship in harbor. All the various appliances were evidently kept in splendid order, and each boat's crew as fully acquainted with its duty as circumstances permitted. The ship had, however, a faint list—less than one degree—but that alone was sufficient to cause quite apparent difficulty in manipulating the boats.

The sensitiveness in this respect of the usual davit is, therefore, one of the greatest of the many drawbacks incidental to the system. Three to four degrees list of the ship instantly reduces its boat capacity by one-half. The British Board of Trade regulations consequently prescribe, in the case of cargo steamers, that the ship shall carry sufficient boats *on each side* to accommodate the whole crew. That a similar rule does not apply to passenger

steamers, where evidently it is so much more called for, is simply the result of the practical impossibility of carrying it into effect.

But the objection which cuts to the very root of the evil is that the system does not and cannot give the crew proper control in handling the boat. The slightest rolling motion of the vessel, when once the guys are loose, is apt to throw the boat into a swinging motion highly dangerous alike to itself and the crew.

Without prosecuting this criticism further, I will now formulate the principal requirements of an ideal system of davits, such as they present themselves to me after several years of keen and careful study:

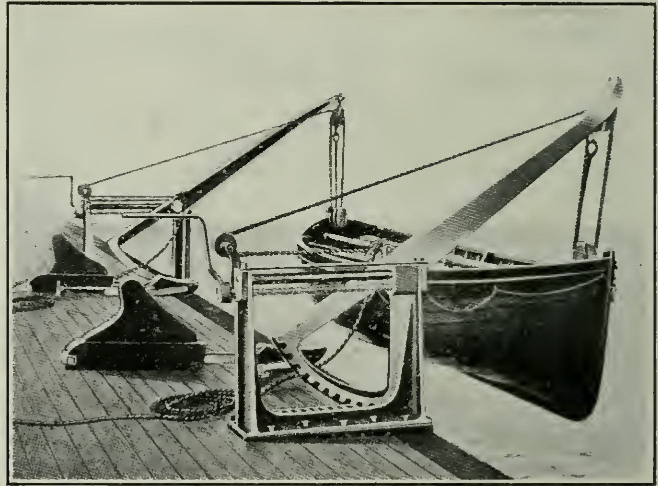


Fig. 1a

1. The boat must in all circumstances, and in every position, be under efficient control.

2. A moderate list of the ship must not prevent or appreciably retard the manipulation of the boat.

3. The mechanism should be of the simplest possible nature, with all its parts get-at-able.

4. The manner of manipulating the davits must be such as to preclude any necessity for expert training and all possibility of confusion in cases of accident.

5. Cost, weight and deck space occupied are all matters which must be taken into account, even if they do not come within the

scope of the subject, when treated from a strict "life-saving" point of view.

Reverting to the Welin Quadrant davit, I first wish to emphasize one or two purely mechanical points of interest:

1. THE HORIZONTAL TRAVELLING MOTION GIVEN TO THE DAVIT ARM.

The advantages of this arrangement in regard to leverage are apparent at first glance. Say that the distance between the keel lines of the boat in the two extreme positions is 10°, and the travel of the moving fulcrum 3°, the load lever when greatest is 30% less than would be the case with a davit turning on a fixed center, while the working lever (the radius of the quadrant) remains constant throughout the movement (Fig. 1a).

2. THE COMPENSATING ARRANGEMENT OF THE FALLS.

Instead of attaching the falls direct to a belaying pin on the davit proper, they are first led over the sheaves as seen in illustration (Fig. 1b) then belayed on the quadrant. The result is that the pull on the falls tends to raise the davit and, though it sounds like a paradox, part of the weight of the boat itself is thus utilized for lifting it inboard. The explanation is easy.

In hoisting the boat from the water it is lifted some distance higher relatively to the upper block than would be necessary if the falls were to be belayed direct on the belaying pin without first being run over the said sheaves, and then, as the davits are swung inboard, the boat drops back. The distance of this drop, multiplied by the weight of the boat, represents the assistance obtained in manipulating the handles, e. g., if the weight of the boat is 30 cwt. and the drop 18″, the gain would be $2\frac{1}{4}$ ft. tons, not deducting anything for additional friction and stiffness of ropes.

I do not wish to weary you with further details of the gear itself, but proceed to describe some typical installations of it.

Generally speaking the boats are placed at a distance from each other of about five feet, which is sufficient for the working of two single davits between the boats. A more compact and perhaps neater looking installation is that formed by double or twin davits between the boats. Some firms, however, object to the use of twin frames on the ground that only half the number of boats

in each row can be swung out simultaneously. The objection admittedly only holds good in regard to boat drill, when, of course, it is more imposing to see all the boats going out precisely

Fig. 1b

at the same moment. In actual use the lowering of all the boats simultaneously into the water would, even under favorable circumstances, invite confusion and disaster.

When the fitting of single frames is insisted upon, but the

length of available deck does not admit of the boats being placed five feet apart, a distance piece is dropped over the handles to prevent these from fouling each other, or a special bevel gearing is fitted.

Occasional difficulties have arisen where an excessive outreach has been required. In simple cases where this has merely been caused by the adoption of a particularly wide belting or rubbing strake, it has been surmounted by shifting the center pin of the quadrant relatively farther towards the back of same, and this, coupled with the throwing out of the outboard end of the frame a few inches, has, so far, proved equal to all demands (Fig. 2).

In the cases of battleships, however, where the boats are so frequently carried on lofty superstructures situated at some distance inboard, the problem has presented more features of interest, especially when the heavy weights of boats, usually carried in vessels of this class, be considered.

Increasing the length of the arm is not a practice which can be continued indefinitely, as apart altogether from the resulting strains and stresses of the metal itself, there is a limit where the excessive labor consequent upon an increased leverage is such that a quadrant davit would offer little or no advantage over the present battleship arrangement for slinging out boats by means of derricks or similar appliances. The plan adopted to gain the end required, while retaining to the full the advantageous arrangement of the quadrant, has been arrived at by what may be termed differential radii (Fig. 3) being given to the quadrant, with the result that while the boat may be slung out with perfect ease, there is no special difficulty attaching to bringing the same home again, the greatest lever being available when most needed.

Whatever criticism you pass on the Welin Quadrant Davit as a mechanical contrivance, I am bound to say that its adaptability to all kinds of arrangements of the boats has fairly astonished me. Here are a few examples:

Fig. 4 shows a boat checked half outboard thereby saving for promenading purposes some 120 square feet of deck space in the case of each individual boat. These are as safe as when stowed inboard and need only be swung in when the ship enters harbor. To do so requires a fraction of a minute.

The fact that the davit arm always remains in a locked position unless manipulated by means of the screw is one of the more im-

portant points about this system. I have included a scale diagram of a ship in section (Fig. 5) having a list of 8°, wherein you may notice the boats in different positions. In connection herewith I can do no better than quoting a few lines out of a testimonial from the North German Lloyd based upon prolonged trials:

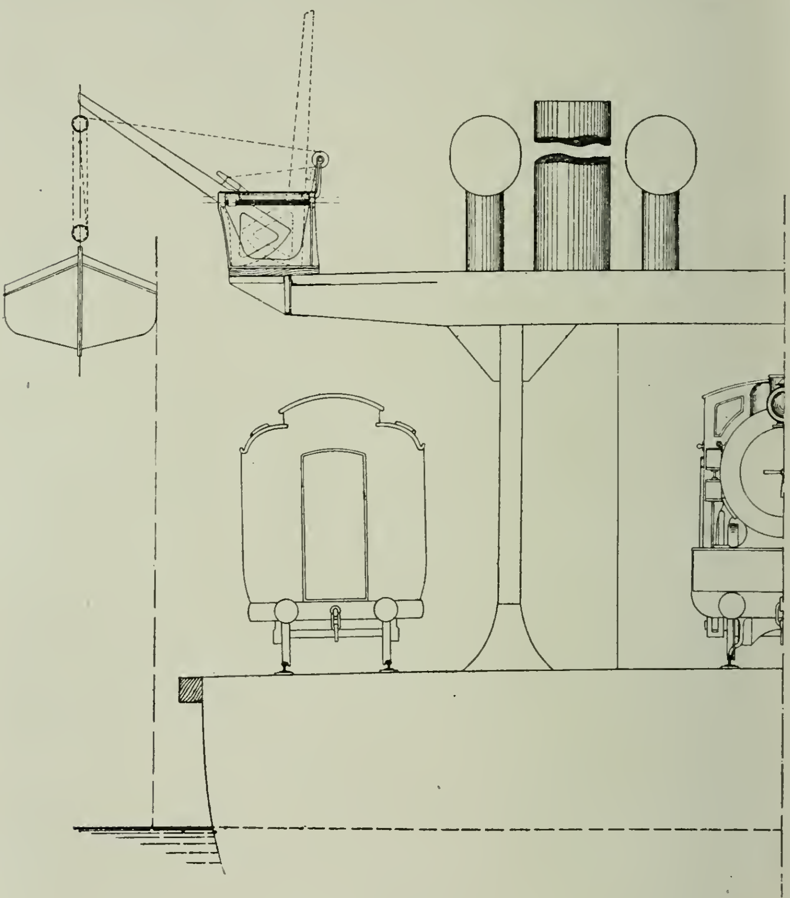


Fig 2

"With a list of 11° of the ship the boat on the high side "was put out in 45 seconds. When the ship was rolling to a "fair degree this was again done in one minute by four men, "and the superiority of these davits, in so far that they re- "main stationary at any point without guying, then became "apparent."

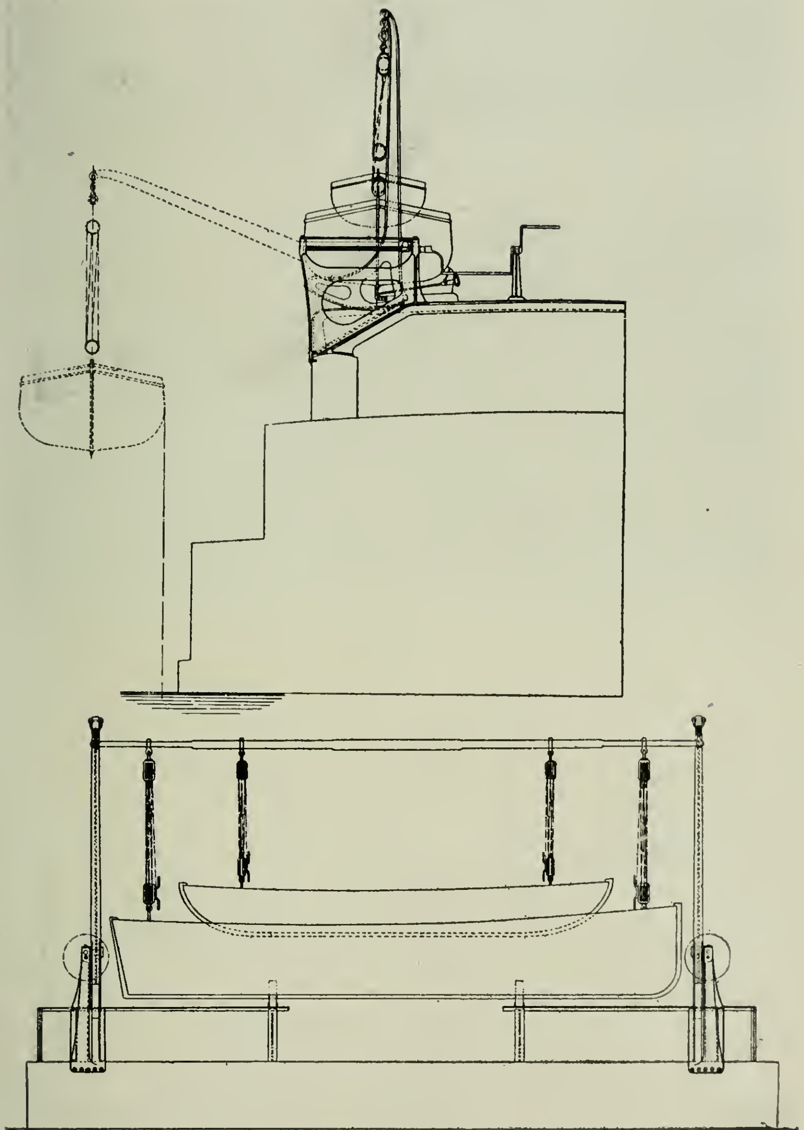


Fig. 3

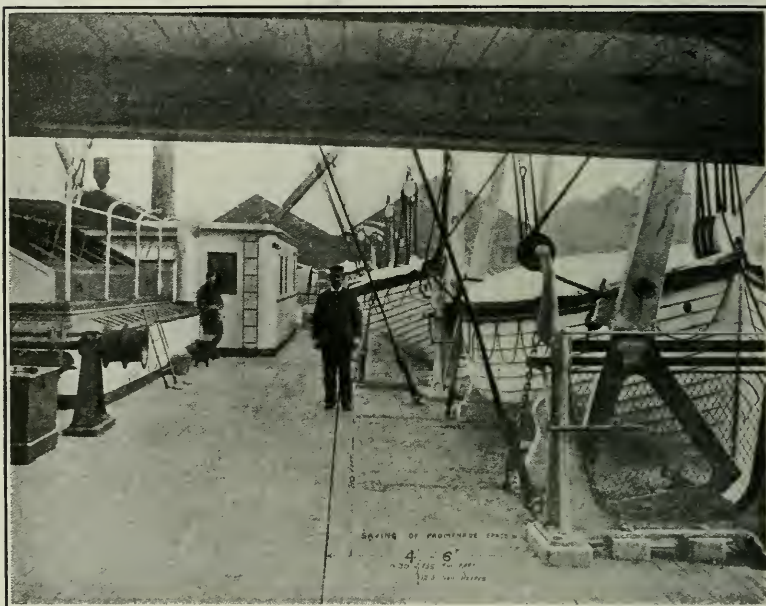


Fig. 4

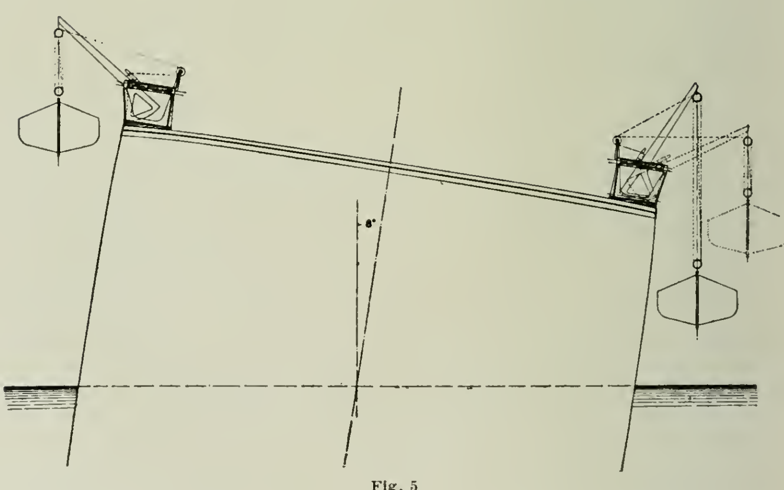


Fig. 5

A further convincing example of what may be accomplished in this direction reached me only last week in a report received from one of the foremost shipbuilding firms on the Clyde:

> "Your davits on the port side had a big test the other "evening. It appears that this steamer took a dangerous list "owing to coal in starboard bunkers, and to right her the "boats were swung out and filled full of water; this had the "desired effect."

A row of boats placed abreast on the top of a deck house may be run out one after the other to the edge of the deck on either side, picked up and swung outward by the davits. No other gear that I know of lends itself so admirably to a plan of this kind. Fig. 6 shows a modification of the davit itself, by which, if the use of a rail arrangement is undesirable, a boat standing inboard of another may be picked up direct from its chocks and swung outboard.

More than 150 ships have now been supplied with davits of the Welin Quadrant type, and it goes without saying that imitations should begin to appear, one— so-called "improved balanced Quadrant Davit," having a counter weight attached to the quadrant, has been put forward, but so far there has been no occasion to stop these infringements.

Figs. 7 to 9 show a few steamers of different types fitted with the Welin davits.

One of the more important European steamship companies has for a great number of years been experimenting with different patent davits, and its engineers have come to the conclusion that any device directly endeavoring to connect—to throw into one—the two distinct movements of swinging the boat over the ship's side and lowering it into the water is doomed to failure; and I believe this view to be correct. Fig. 10 illustrates a simple winch gear that can be readily applied to the Welin Quadrant davit for lowering and hoisting purposes. Where wire instead of manilla falls are used a clutch brake attached to the davit, conveniently of the form shown in Fig. 11, might be used, particularly on large steamers where they always have steam or electric winches centrally located for hoisting purposes.

NOTE.—The vessel referred to is 5,500 tons gross, and is fitted with five 28 ft. x 8 ft. 6 in. lifeboats on each side.

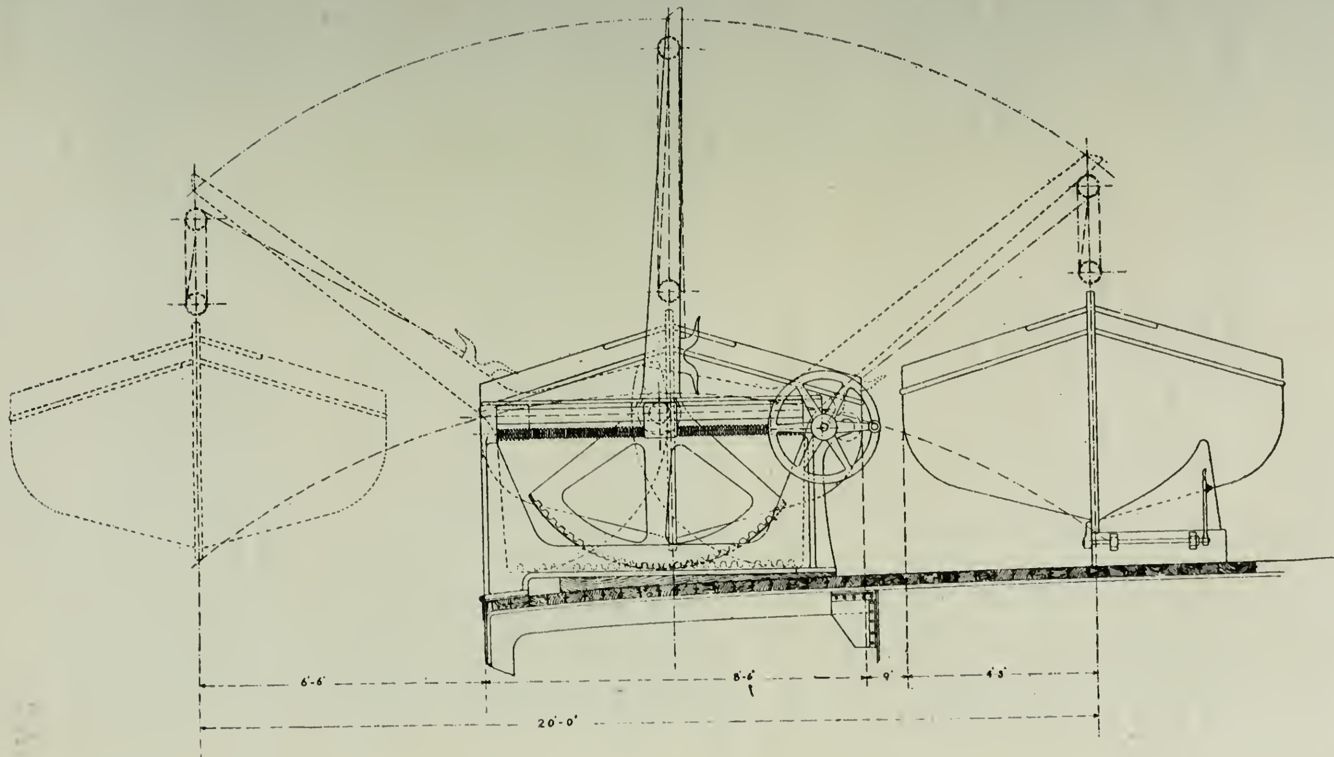


Fig. 6

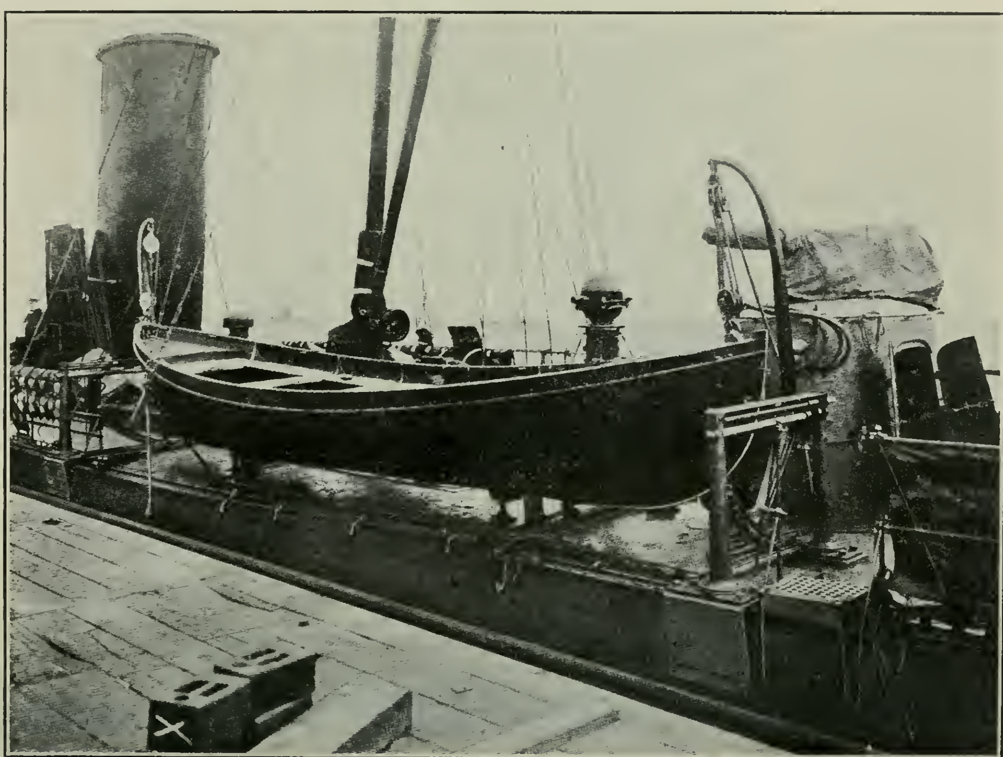


Fig. 7

I now propose to anticipate one or two objections which are certain to present themselves to some of the members present:

WHAT OF ICE?

Well, my answer is simple enough. This gear, as well as everything else on deck, given the opportunity, may freeze up. Still, I am able to state that in no single instance, except in the one re-

Fig. 8

lated below, has such a thing happened with all the many davits which have now for several years regularly travelled across the Atlantic, and on other cold routes. Nearly four years ago I fitted a couple of experimental sets on a German Atlantic Liner, and the captain received orders from headquarters to freeze up the gear and then ascertain whether it would work or not. It took him two years to do this, and when accomplished, he found it necessary to crush the ice on the frame base before the davits could be run out.

To condemn the gear on such evidence would, I think, hardly

be fair. The ordinary wrought iron davit might get its block, tackle, collar and socket clogged in the same way. But even disregarding this, in what state would the deck itself be if the gears had been choked by ice? To manipulate a thirty-foot lifeboat by means of a pair of ordinary davits from a deck coated with ice would indeed be an anxious job for the officers in charge. Try and put yourselves in his position, and I do not think you will

Fig. 9

hesitate long in choosing your type of davit. To meet all objections on this score, I have, however, designed a frame with open teeth, permitting the ice to be crushed through by the teeth on the quadrant when travelling along the rack.

WHAT ABOUT WEIGHT AND STRAIN ON DECK?

In replying to the first of these questions I may state that, especially with heavy boats, there is considerable saving in weight as compared with the ordinary round solid bar davit. The hollow Mannesmann tube davits, otherwise of the ordinary type, are,

however, somewhat lighter. As regards the second point, the only strengthening of the deck hitherto required in the great majority of cases has been a piece of channel bar fitted between two of the deck beams to divide the upward strain between these and to receive the bolts at the inner end of the frame. In cases of particularly flimsy decks, the subject must, of course, have some consideration.

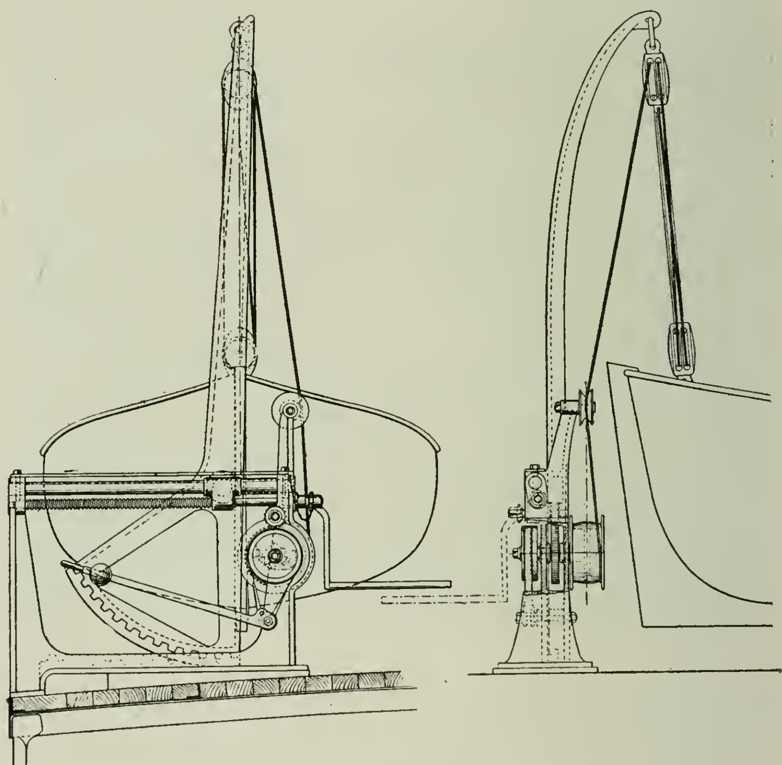


Fig. 10

(In the instances cited above where, with the object of righting a badly listed vessel, five water-laden boats of an aggregate weight of some sixty tons, were slung simultaneously overboard, the deck, although of quite ordinary scantling, and without any previous preparation, was in no way strained by the proceeding, severe as it was.)

Before concluding I must take up a remark which has been put to me on more than one occasion: "What is the good of taking so much trouble over a question like this? The chances of ever getting any lifeboat safely into the sea from the tremendous height at which they are placed on present-day Liners are so remote that it is useless to hope for success, whatever davits are adopted."

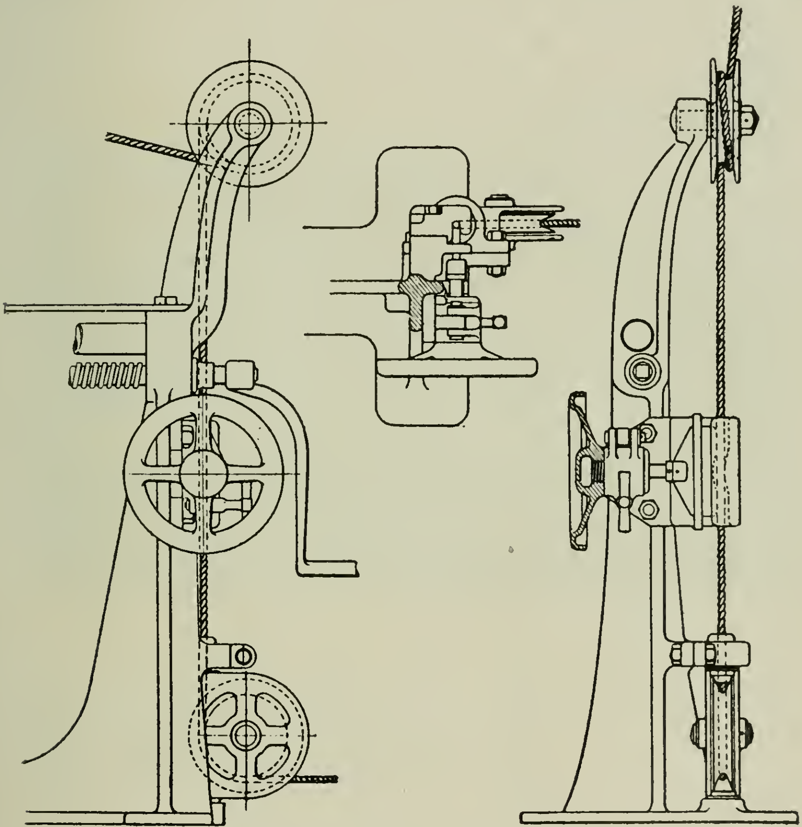


Fig. 11

That is hardly sound reasoning, but it contains a great deal of truth all the same. Sooner or later some different plan of placing the boats must and will be adopted; it is only a question of time.

Some eight months ago, I put a suggestion on the lines illustrated in Fig. 12 before a prominent firm of shipbuilders on the Continent, without, however, at the time, obtaining any definite

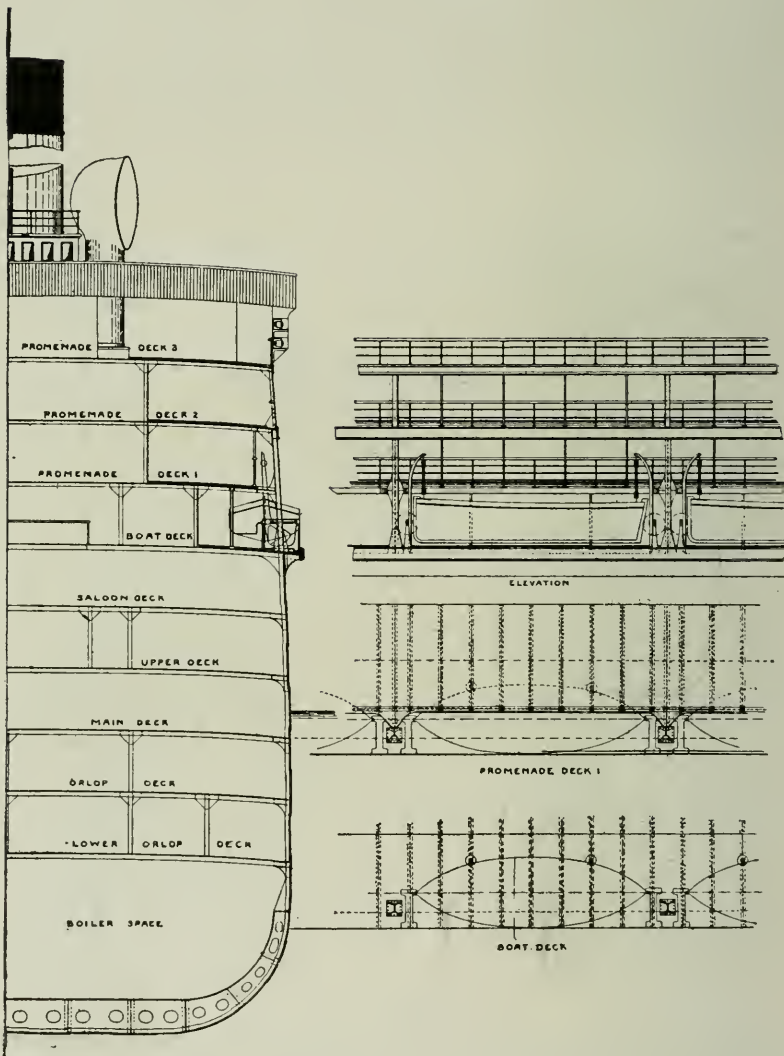

PROMENADE DECK 3
PROMENADE DECK 2
PROMENADE DECK 1
BOAT DECK
SALOON DECK
UPPER DECK
MAIN DECK
ORLOP DECK
LOWER ORLOP DECK
BOILER SPACE
ELEVATION
PROMENADE DECK 1
BOAT DECK

Fig. 12

results. I am, of course, fully alive to the many difficulties in the way of getting some such scheme adopted, and it may require a few more of those disasters which stir humanity to its very core, before conservatism can be made to budge.

Shipbuilders do not, as a rule, welcome deviations from orthodox designs; that such deviations, possibly resembling the one foreshadowed above, must ultimately come, nevertheless I am more than ever confident. At a time when scarcely a month passes without witnessing the birth of some new leviathan, each exceeding its forerunner in speed and passenger bearing capacity,

Photograph showing how the old style Davit can freeze up when given the opportunity.

the compelling necessity for such vessels to be fully supplied with lifesaving appliances of the highest order, is a fact which cannot fail to thrust itself with an added force and conviction upon the observation of the most callous.

In bringing these remarks to a close, and speaking as far as it is possible for me, from an impartial standpoint, I venture to assert that if ever there was a moment when the matter so briefly dealt with in this paper, called for careful and renewed consideration, that moment is now, when the gigantic creations of recent months and the rumors of even greater things in the near future, bring to the whole subject a new significance.

ALASKA COAL FIELDS.

Of the 600,000 square miles forming the Territory of Alaska, it is estimated that 12,644 square miles are underlain by coal-bearing rocks—that is, rocks that probably contain coal seams—and that 1238 square miles contain workable coal, ranging in age from Carboniferous to Tertiary and in composition from anthracite of good quality through high-grade semi-bituminous steam and coking coals and ordinary bituminous coal to lignites of various characters. Many of the known coal deposits are of great thickness, especially where the coal carries a large carbon content; but, unfortunately, high grade of coal and great thickness of beds are as a rule accompanied by geologic structure unfavorable to mining.

From the Pacific Coast to Behring Sea and the Arctic Slope, through the valleys of Copper and Yukon Rivers and their tributaries, coal beds are widely distributed; and although it is unlikely that any except the high-grade coals of the Pacific Coast and the Matanuska and Behring River fields are suitable for shipment far from the mines, many others may be locally of extreme importance and great value.

The coal-mining industry of Alaska is still practically undeveloped, the total production for 1906—the year of greatest output—being 6660 short tons, valued at $20,000. The most active mining operations have been in Cook Inlet, in southwestern Alaska, on the Yukon, in Seward Peninsula, and at Cape Lisburne, all undertaken to provide fuel for local use, by small coastwise or river steamers at mining camps and at canneries.

Alaskan coals have in recent years been the subject of a large amount of special investigation by the Geological Survey and in addition much information concerning coal has been gathered each year since regular geologic work was begun in Alaska by Survey parties working primarily on other problems. A brief summary of the results of these investigations, illustrated by a map showing the distribution and area of coal and coal-bearing rocks is included in the Report on Progress of Investigations of Mineral Resources of Alaska in 1906, published by the Survey as Bulletin No. 314. This summary, prepared by G. C. Martin, is not intended to be complete in itself, but it supplements more complete and comprehensive summaries which have been already published and to which reference is made, and is preliminary to more detailed discussions that will be published on the completion of investigations now in progress.

The work of the season of 1907 will include studies of the coal-bearing rocks of the southeastern part of the Territory and of the Yukon coal fields so far as they are accessible from Yukon River. Field work was begun early in May by W. W. Atwood, who is assisted by H. M. Eakin, and Mr. Atwood reports the work in southeastern Alaska already completed. It is believed that the investigations this year will add materially to existing knowledge of the coal resources of the Territory.

GLASS-SAND INDUSTRY OF THE OHIO VALLEY.

Approximately $65,000,000 worth of glass products were manufactured in the United States in 1905. The materials used cost about $18,000,000, and of this sum $1,000,000 was spent for sand. Within the half century preced-

ing 1900 the value of glass products showed an average increase of 70 per cent. for each decade, and the growth is still vigorous. In view of the remarkable development of an industry so largely dependent for its raw materials on mineral deposits the United States Geological Survey has been making an investigation of sand-producing areas. This investigation, begun in 1905, in the Mississippi Valley, was extended in 1906 to the Ohio Valley, and a brief report on the work, prepared by Mr. Ernest F. Burchard, has been incorporated in Bulletin No. 315, Contributions to Economic Geology, 1906.

The major constituent of glass is sand, which forms from 52 to 65 per cent. of the mass of the original mixture or from 60 to 75 per cent. of the finished product. To the sand is due the absence of color, the transparency, brilliancy, and hardness of glass. That is, the quality of the glass depends chiefly on the quality of the sand. To the producer the physical conditions affecting quarrying and mining, the amount of sand available, and the location of the deposits with respect to transportation routes and markets are as important as is the quality of the sand.

Of the States in which glass is listed as a manufacture, Indiana and Ohio at present occupy respectively second and third rank, the first place being held by Pennsylvania. Glass making has but recently been added to the industries of Kentucky, but factories are in operation at two points.

From statistics quoted by Mr. Burchard it appears that Indiana is producing less than 1 per cent. of the glass sand used in the State, the remainder being obtained largely from the Fox River (Illinois) district and the Klondike (Missouri) district. All the sand that can be produced of sufficient purity even for green and amber bottles finds a ready market at good prices—a condition encouraging to both producers and manufacturers. Attention is called, however, to the fact that no large deposits of sandstone are known in Indiana that have the purity of the St. Peter sandstone, so abundant farther west, and for certain grades of glass there will always be a demand for the sand from beyond the State.

Ohio, acording to the statistics, produced 0.937 per cent. as much glass sand as is used in the State. A large part of this, however, passes from the eastern part of the State to factories in western Pennsylvania, and a corresponding amount is brought in from other States, especially from West Virginia and Illinois, at notably higher prices. Glass works are established within an area extending across the State from Toledo to Cincinnati and as far east as Steubenville. The plants are usually well situated in regard to fuel, but many have to pay excessive freight charges on their sand.

The Kentucky factories obtain their sand at Tip Top, twenty-eight miles southwest of Louisville.

Mr. Burchard's paper discusses briefly the rock formations which in Ohio, Indiana, and Kentucky furnish sand suitable for glass making, and gives descriptions of the various properties now being developed. Requests for Bulletin No. 315, which can be obtained free of charge, should be addressed to the Director, United States Geological Survey, Washington, D. C.

GAS IN SOUTHEASTERN KANSAS.

Gas has been discovered in ten counties of the 105 in the State of Kansas. Its history and distribution in the Kansas-Indian Territory field are so closely connected with those of oil as to be almost inseparable. About the year 1860 the numerous shallow oil wells drilled to depths of a few hundred feet in Southeastern Kansas yielded traces of natural gas as well as of oil. Twenty years later, gas in small quantities was found in a number of places near Independence. The first good gas well in the vicinity of Neodesha, which is now a center of production of gas as well as of oil, was drilled in 1893. The present production of gas in the Independence quadrangle is enormous. The value of the quantity now annually consumed in the quadrangle alone is estimated to be about $800,000.

More gas sands than oil sands are encountered in the drilling of individual wells. This oil may be found above the gas or below it. The gas is believed to come mainly from depths of 1800 to 2300 feet.

Thus far most of the gas has been put to local use. It furnishes the light, fuel and power of practically all the cities and most of the farm communities and is extensively used for fuel in drilling and pumping. It also supplies the city of Parsons and its numerous industrial plants east of the quadrangle. All this, however, forms but a small percentage of the quantity consumed and to be consumed by the manufacturing industries which have grown out of this natural commodity. Of these industries the most important are those producing brick, tile, pottery, glass, cement, zinc, and lead.

MONAZITE AND ZIRCON IN 1906.

The monazite produced in the United States in 1906 all came from North and South Carolina. The output of crude sand amounted to approximately 2,000,000 pounds, averaging about thirty per cent. monazite. The grade of this sand was so variable and the prices realized on different lots were so irregular that cleaned sand has been used as an estimate of the quality of monazite produced, an additional reason for so doing being furnished by the fact that the greater part of the crude material is cleaned by local mills before shipment, and the grade brought up to 80 per cent. or more of monazite. On a basis of 80 per cent. production, North Carolina produced 697,275 pounds, and South Carolina 148,900 pounds, valued at $26,802; the total for the United States amounting to 846,175 pounds, valued at $152,312.

The production for 1905 amounted to 1,352,418 pounds, valued at $163,408. This amount represented in part crude and in part cleaned sand—a fact that explains the increase in quantity without corresponding increase in value.

The zircon produced in 1906—all from Henderson County, N. C.—amounted to 1,100 pounds, valued at $248.

The condition of the monazite market in the United States in 1906 was fairly strong, despite the fact that the price of thorium nitrate, which is manufactured principally from monazite, was reduced nearly one-half early

in the year by the German thorium combine. Though made with the intention of killing all competition, this cut has resulted only in the temporary closing down or the bankruptcy of a few of the smaller companies.

The economic value of monazite lies in the incandescent properties of the oxides of the rare earths—cerium, lanthanum, didymium, and thorium—which it contains. The cerium goes to the drug trade; the thorium, together with limited quantities of lanthanum and didymium, is used in the manufacture of mantles for Welsbach and other incandescent lights.

TRIPOLI DEPOSITS IN CALIFORNIA.

The diatomaceous deposits so widely distributed in the Coast ranges of California are found in such purity and such inexhaustible quantities in northern Santa Barbara County as to give them great commercial value, and it is for this reason that a description of the occurrences is included by the United States Survey in the Contributions to Economic Geology for 1906 (Bulletin No. 315). The paper was prepared by Messrs. Ralph Arnold and Robert Anderson as the result of field work in 1906 in the Lampoc and Guadalupe district.

The deposits are variously known as infusorial earth, tripoli, diatomaceous earth, and, in Santa Barbara County, "chalk rock." The most appropriate of these names is diatomaceous earth, and as the material is composed almost entirely of the skeletons of minute organisms, called diatoms—one-celled plants that adapt themselves to a wide range of conditions of depth and temperature in fresh or salt water and secrete siliceous casings around their organic matter. They must have lived in great abundance in the sea that ages ago covered this part of the land, for the rock was built up of the little shells of these plants that dropped to the sea bottom. Examination with a hand lens always reveals a large number of the round forms of the diatom shells thickly imbedded in the shale. Many of these shells are in a good state of preservation, and in some of the material they can be plainly distinguished with the naked eye. The name "chalk rock" is inappropriate, for although the deposits resemble chalk in appearance, they are made of siliceous instead of calcareous material.

The uses to which the diatomaceous earth are put are constantly increasing, and the methods of application are developing. Formerly employed solely for abrasive purposes, it soon became useful in the manufacture of polishing powders, soaps, etc.; but its abrasive quality is not its most valuable one. Its porosity makes it a good absorbent, and it is extensively used in the manufacture of dynamite from nitroglycerine. Being very light and a poor conductor of heat, it is valuable for use in the manufacture of packing for safes, steam pipes, and boilers, and of fireproof building materials. It also serves as a base for the manufacture of cement suitable for withstanding heat. It is a good filtering substance and is so used commercially. Some of the earth from the Lompoc region is said to be used in the refining of beet sugar. In the Lompoc region and also at Monterey, farther north on the California coast, it is used in the

construction of buildings. The shale is easily quarried into smooth blocks which can be readily placed in position. The blocks are compact and yet elastic under changes of temperature, seem to possess sufficient strength, and are very resistant to weathering. As a building material it is finely adapted to a region subject to earthquakes, for the shock effect on a substance so light would probably be the minimum and a smaller amount of damage would result from falling materials. The Santa Barbara County deposits are rendered exceptionally valuable by their proximity to railroad and ocean transportation facilities.

The paper referred to includes descriptions of the various occurrence of the diatomaceous earths, a discussion of their physical and chemical properties, and the statistics of production in the United States. It may be obtained by applying to the Director, United States Geological Survey, Washington, D. C.

MEASUREMENT OF ICE-BOUND STREAMS.

The laws governing the flow of rivers that that are frozen over have recently been investigated by members of the United States Geological Survey. A paper entitled "Determination of Stream Flow During the Frozen Season," by Messrs. H. K. Barrows and R. E. Horton has been published in which the effort is made to formulate methods for estimating the flow under such conditions and important recommendations as to methods are made.

Estimates of the flow of rivers are made in all parts of the country. To a great extent they are based on daily gauge readings and numerous current-meter measurements. In the northern and central parts of the United States the streams may be closed by a more or less permanent ice cover for a considerable portion of the year. This period varies from nearly five months in the extreme north to a few weeks or less in the Central and Atlantic States. The methods in use for estimating flow under open-channel conditions have become well defined, and the limits of accuracy are known to be reasonable. On the other hand, the study of the flow of streams under ice cover is but just started, and in order to systematize the accumulation of data and to provide the material in convenient form for future use it is desirable that certain general methods be followed.

As estimates of flow, to be of conclusive value on streams utilized for water power, must embrace these winter periods of low water, it is easy to see the importance of this inquiry.

THE SOURCE OF RADIUM.

Doubts have been cast on the generally accepted theory that radium is a decomposition production of uranium, says *Nature*. A recent investigator showed that, starting with solution of uranium nitrate carefully purified by repeated crystallization, the amount of radium formed in eighteen months was less than 1-2000 of the amount which the disintegration theory called for. In a recent experiment upon the growth of radium from actinium, this same scientist decomposed a kilogram (2.2046 lb.) of carnotite ore, con-

taining about 20 per cent of uranium, and an excess of hydrochloric acid. This solution was then so treated as to separate the actinium from the other constituents. It was secured in the form of a chloride, which was then sealed in a glass tube. After two months the gases from the tubes were placed in an electroscope and the activity of the emanation determined. The tube was then resealed and allowed to remain for several months longer. The emanation at the end of this time was found to indicate an activity corresponding to three times the former amount of radium. From this rate of increase it is computed that the half period for the evolution of the emanation would be about 3100 years. Since the amount of actinium in a mineral is apparently always proportional to the amount of uranium and radium present, it is thought that actinium may prove to be the looked for intermediate product.—*Iron Age.*

PRODUCTION OF BARYTES IN 1906.

Barytes, or heavy spar (barium sulphate), is used principally as a white pigment, although it is also employed in the manufacture of paper, cloth, and rubber. It occurs in veins as a gangue of metallic ores, in veins in sandstone and limestone, and as a replacement of limestone. Differential weathering of the limestone and the barytes has given rise to deposits of barytes embedded in residual clay. The principal deposits in the United States have been found in Missouri and in the Appalachian region, in Virginia, Tennessee and North Carolina. Small deposits also occur in Pennsylvania, and in 1906 Alabama became a producer of this mineral.

In 1906 the quantity of crude barytes mined in the United States amounted to 50,231 short tons, valued at $160,367. This value is that of the crude barytes at the mines, hand cobbed and ready for shipment. This production shows an increase in quantity of 1996 tons and in value of $11,564 over that of 1905, which was 48,235 short tons, valued at $148,803. The value per ton has advanced from $2.66 in 1904 to $3.19 in 1906. Missouri is the largest producer, Virginia being second.

An advance chapter from "Mineral Resources of the United States, Calendar Year 1906," by E. F. Burchard, on the production of barytes in 1906, with a note on strontium, is now ready for distribution.

ANTHRACITE COAL PRODUCTION IN 1906.

An advance chapter from "Mineral Resources of the United States, Calendar Year 1906," on the production of anthracite coal in 1906, prepared by the United States Geological Survey, by William R. Ruley, coal expert, is now ready for distribution, and copies may be obtained on application to the Director of the Survey at Washington, D. C.

Mr. Ruley states that the production and consumption of anthracite in 1906, amounting to 63,645,010 long tons, shows a material decrease when compared with the tonnage of 1905 (69,339,152 long tons), which was the largest on record; but in view of the reported condition of the industry at the close of December, 1905, the results for 1906 should be regarded as better than had been anticipated.

The zinc smelters of the United States are divided into two groups, viz.: (1) those which make high-grade spelter from special ores, this group including the New Jersey Zinc Company, and the Bertha Mineral Company, producing at Bethlehem and Palmerton, Penna., and Pulaski, Va., spelter from the remarkably pure ore of New Jersey; and (2) those which make spelter from Western ores. The Western spelter up to about 1901 was made almost entirely from ore mined in Wisconsin and the Joplin district of Missouri-Kansas, and was marketed chiefly under the name of "Prime Western." Certain smelters, purchasing selected ores, make superior brands. Since 1901, the quantity of ore from west of the Rocky Mountains has attained large proportions, and the "prime Western spelter" now produced is largely derived from that class of ore. Many of the smelters separate the first draw of metal, which, being distilled at the lowest temperature of the operation, is lower in certain impurities (especially lead) than the second and third draws, and market it as "special." The major part of the Western spelter is produced, however, as ordinary brands, and the prices for ore are based on the prices of good ordinary brands of spelter.—*Eng. and Min. Jour.*

Book Notices.

Commercial Organic Analysis. A treatise on the properties, modes of assaying, and proximate analytical examination of the various organic chemicals and products employed in the arts, manufactures, medicine, &c., with concise methods for the detection and determination of their impurities, adulterations, and products of decomposition, by Alfred H. Allen. Third edition, rewritten and revised. Vol. II. Part III. Acid derivatives of phenols, aromatic acids, resins, and essential oils, revised by the author and Arnold Rowsby Tankard. 547 pages, 8vo. Philadelphia, P. Blakiston's Sons & Co., 1907. Price, cloth, $5.00 net.

The material for this volume was collected by Dr. Allen, and after his death the editorial management was undertaken by Arnold Rowsby Tankard with the collaboration of several specialists. There is much new information on the subject of aromatic acids and the articles on resins and the essential oils have been entirely rewritten. The volume is uniform with those previously issued. R.

The Transit, Vol. XII, 1907, published annually by the Engineering Society of the State University of Iowa. 102 pages, illustrations, portraits, plates, 8vo. Iowa City, 1907.

The present volume contains an interesting and varied number of papers on topics relating to modern engineering practice in addition to information which is of special interest to the students and graduates of the University. R.

Die Metalle Geschichte, Vorkommen und Gewinnung nebst ausführlicher Produktions-und Preis-Statistik. Vom "Verein zur Beförderung des Gewerbefleisses" preisgekrönte Arbeit von Dr. phil. Bernhard Neumann. 421 pages, plates, table, 8vo. Halle a. S. Wilhelm Knapp, 1904.

We have here in convenient form a history of all metals, those com-

monly known as well as the rare ones. The work deals with the discovery, production and use of the metals among various nations and during all ages, and describes briefly the development of the metal industry of all countries.

There is much statistical information relating to production, prices, &c., brought down to the year 1900, and in many instances later. The author has spent a number of years in collecting his material and was awarded the Tornow prize by the Society for the Production of Trade Industry, Berlin. The work will be useful for reference. R.

Annuaire pour l'an 1908. publié par le Bureau des Longitudes. Avec des notices scientifiques. 950 pages, illustrations, 24mo. Paris, Gauthier-Villars, n. d. Price, in paper, 1 fr., 50c.

The one hundred and twelfth issue of this annual has just been sent out by the publishers. It contains the usual amount of interesting and useful information relating to astronomy, physics and chemistry.

Among the special articles included in this volume is one by M. G. Bigourdan on the Distances of the Heavenly Bodies, with special reference to the Fixed Stars; and another on the School of Practical Astronomy of the Montsouris Observatory, by M. F. Guyon. A. R.

Moving Loads on Railway Underbridges, including diagrams of bending moments and shearing forces and tables of equivalent uniform live loads. By Harry Bamford, M. Sc., A. M. Inst., C. E., Lecturer on Engineering. Drawing and Design, Glasgow University, formerly Associate Professor of Hydraulics, McGill University, Montreal. Whittaker & Co., London, 1907. 78 pages, 6½ x 8 in., flexible cloth. Price, 4s 6d.

Beginning with the simplest cases, the author, by gradual steps and in detail leads to the more complex problem of determining bending moments and shearing forces of simple beams under locomotive wheel and team loads.

The use of the usual form of force and equilibrium polygon for this purpose is described and illustrated in detail, and methods are given for quickly locating beams of different spans on the equilibrium polygon for maximum moments and shears from which diagrams of equivalent uniform loads for varying spans are constructed. The analytical method is also set forth and for comparison applied to a problem solved by the graphic method.

For determining the location and value of greatest maximum bending moment, the diagram used is quite expeditious, but where the purpose is to determine maximum moments at other points without relying upon the equivalent uniform load, the method described by Ward Baldwin in "Engineering News," Vol. XXI, pages 295 and 345, and Dec. 11th, 1889, page 615, and now widely used, seems better adapted.

The proofs given are clear, thorough and amply illustrated, and the work may be recommended as an excellent aide-memoire to the commercial engineer or to the student seeking a lucid explanation of the subject. L. E. P.

Sections.

Section of Physics and Chemistry.—A regular meeting of the Section was held this evening at 8 o'clock. Dr. Robert H. Bradbury in the chair. Present, sixty-four members.

The paper of the evening was read by Dr. Harry F. Keller, of the Central High School of Philadelphia, on "The Transmutation of the Elements." The speaker gave an admirable historical resumé of the subject, illustrated by a large number of lantern photographs.

The subject was freely discussed, and at the close the speaker was tendered a vote of thanks. Adjourned.

Edward A. Partridge, *Secretary.*

Section of Photography and Microscopy.—A regular meeting of the Section was held this evening at 8 o'clock. President Dr. Henry Leffmann in the chair. Present, forty-four members.

The following communications were presented: Photographing Moving Water (with numerous striking illustrations), by Mr. J. W. Ridpath. Mr. Richard W. Gilpin exhibited a series of characteristic photographs.

Brief Notes on the Early History of Photography in Philadelphia, by Mr. Alfred Rigling. (Read by Dr. Leffmann.) The paper was illustrated by the exhibition of several early cameras.

Wm. H. Wahl, *Sec'y pro tem.*

The Franklin Institute.

(*Proceedings of Stated Meeting held Wednesday, March 18, 1908*)

Hall of the Institute,

Vice-President Henry Howson in the chair.

Present thirty eight members and visitors.

An election was held for two members of the Board of Managers, to fill vacancies caused by the election of Mr. Cyrus Borgner to the Treasurer, and the death of Mr. George V. Cresson. The ballot resulted in the election of Mr. Chas. Day and Mr. Morris Ebert, both to serve one year.

The paper of the evening was read by Mr. Harry P. Cochrane, of Philadelphia, on the subject of "Engineering Practice as Applied to the Equipment of Power Houses."

The paper was discussed by a number of members. On Dr. Wahl's motion the thanks of the meeting were voted to the speaker, and his paper was referred for publication. Adjourned.

Wm. H. Wahl, *Secretary.*

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FOR THE PROMOTION OF THE MECHANIC ARTS

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THE FRANKLIN INSTITUTE.

The Waterways Problem.

BY LEWIS M. HAUPT, C.E.; A.M.; Sc.D.

Prof. of Civil Engineering, Franklin Institute.

The report of the Inland Waterways Commission, appointed by the President in March of 1907, again calls attention to the urgent need of some drastic measures which will relieve the country from the inadequate facilities for the removal of the enormous tonnage which the nation produces. In referring to the report in his message the President characterizes it as the conservative, sane and just judgment of a body of exceptionally well qualified experts, and adds that if it errs at all it is by over-conservatism. "The subject of which it deals is of critical importance, both to the present and to the future of our country."

Being in full accord with these sentiments and realizing the urgency of a speedy conclusion which shall make provision for the opening of the magnificent systems which the United States affords for internal transportation by water, it seems appropriate

to review briefly the actual situation and the remedies suggested, not in a spirit of criticism, but with a view to an early remedy.

Although the rivers have continued to flow to the seas for many centuries and projects have been on the tapis for generations, he has aptly said that "*The rivers of no other civilized country are so poorly developed, so little used, or play so small a part in the industrial life of the nation as those of the United States.*"

The reasons for this condition are ascribed largely to "unregulated railroad competition," which has tapped the traffic at its origin and confined it to wheels, whereas it is abundantly shown by experience in all countries that the proper segregation of the bulky freights to the water routes is the best for all interests, and the greatest masters of transportation and students of economics have for many years been attempting to effect such a separation to prevent the engorgement which has been so manifest in the past.

HISTORY REDIVIVET. SECTIONALISM.

But there are other causes of great potency also which have caused the decadence in the water-borne traffic. Prior to the advent of the railroad as a competitor, there were numerous private companies chartered by the States for the improvement of the waterways as commercial enterprises, authorized to build, operate, and maintain navigable waterways, whether as canals or slackwater rivers, to sell the power stored in the dams and to charge tolls. Under these rights some 5,000 miles of canals were constructed prior to the Civil War at a cost of about $150,000,000, or an average of $30,000 a mile. A century ago the sparse population and limited capital of the States appeared to be insufficient for the great work of connecting the Great Lakes with the seaboard and the "Empire State" solicited the aid of the Nation in the form of a land grant to build the Erie Canal, but after a long discussion and many flattering promises it was finally refused because of the sectional jealousies which led the Commissioners to report to the New York Legislature, in 1811, that:

"On the 21st of December, they waited on the President of the United States (Monroe) and found him, although he expressed himself to be an enthusiast as to the advantage of interior navigation, by means of canals, embarrassed by scruples derived from

his interpretation of the constitution. At the close of their visit, however, he was in better disposition, which is evidenced by his message to Congress, of the 23d of December, copy whereof is annexed. On the 24th they attended at the Treasury office and found the Secretary desirous of performing this, and other works of a similar nature, conformably to the plan which he had reported at the precedent session. He was under the opinion that under present circumstances, pecuniary aid would not be given; but that sufficient grants of land might be made now without inconvenience to the fiscal concerns of the Union.

"Your committee found an idea prevailing with some, and sedulously inculcated on others, that it would *be wise so to amend the Constitution*, as expressly to authorize the general government to incorporate banks and *make roads and canals without the consent of the States.*

"This suggestion arose, they believe, from the desire to resuscitate the national bank. * * * Other objects were introduced rather as a convenient cover than as needful concomitants. Whatever may be the case with respect to banks, the proposed amendment, so far as regarded roads and canals, appeared to your committee to be worse than useless. * * * Your committee felt it a duty to declare, on all proper occasions, a decided opinion that the States *would not consent to vest in the National Government a power to cut up their territory, for the purpose of digging canals.*

"Your committee found another idea operating with baleful effect, though seldom and cautiously expressed. The population and resources of the State of New York furnish no pleasant reflection to men, whose minds are imbued with State jealousies; and although the proposed canal must not only be of the highest importance to the western States, as well as to the States of Pennsylvania and Maryland, and greatly promote the prosperity of the whole Union, it was obvious that an opinion of its superior benefit to this State was sedulously inculcated. An opinion which there is reason to fear will have too much influence in every consideration of this subject. * * *

"It became evident that the object of this State would not be separately attended to and your committee were desired to prepare a general system * * * they had learned, in the course of their conversation with individuals, that unless something was

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*Italics by author.

done for many of the States, the consent of the majority of the House of Representatives could not be obtained." * * *

Thus a log-rolling bill covering a system of canals in most of the States of the Federal domain lying east of the Mississippi, was draughted, and it provided for the appropriation of 9,900,000 acres among the several States, of which New York's pro rata was to have been 4,500,000. The objection, however, was so great that the bill was smothered in sub-committee and New York was compelled to carry on the work from her own resources, thus securing for herself the commercial supremacy of the western world and leaving her sister States without the Federal assistance and internal development they might have secured so readily but for the narrow sectional policy which was permitted to prevail.

In closing their report the commissioners stated:

"Others, again, who have too much understanding to doubt the resources of the State, and too much prudence to expose themselves to ridicule, by expressing such doubt, triumphantly declare, that her Legislature has not the spirit and intelligence to draw out and apply her resources to that great object.

"These men console themselves with a hope that the envied State of New York will continue a suppliant for the generosity of the Union, instead of making a manly and dignified appeal to her own power. It remains to be proved, whether they judge justly who judge so meanly of our councils."

The sequel proved the wisdom of the commission in abandoning further efforts to secure national aid, and these extended extracts may point the moral which has been so oft repeated in subsequent years, of the difficulty in securing enabling legislation for the most important and meritorious national improvements, because of petty jealousies or sectionalism. It follows that under the general provisions of the Constitution and the practice existing prior to the war, that the system was working very satisfactorily and that facilities were created whenever and wherever the prospects seemed to justify a fair return on the capital, whereas at present, private capital is being paralyzed by the inhibition of tolls on waterways, while it has ever been permitted on the railroads, without which they could not exist, and the efforts to regulate the tariffs by legislation is having a direful effect. The rehabilitation of the waterways on a commercial basis would go far

to relieve the railway, while it would also add largely to its more profitable business at less cost for plant and operation.

Thus history is constantly repeating itself, but the lesson of experience appears to be lost in the ever changing personnel of the actors in the legislative and executive departments of the Government.

The present régime and the obligation under which the Government is now laboring are well stated by Senator Philander C. Knox, of Pennsylvania, in his address to the Chamber of Commerce of Pittsburgh, on February 12th, when he said:—

"*The duty of the Government to raise its waterways and harbors to their utmost efficiency was determined long ago by the action of the Government itself. * * * It invited cities to improve their docks to accommodate large ocean vessels. It held out inducements to railways to bring their tracks to the water's edge and construct terminals for the transfer of freight from cars to vessels. So when the Government assumed charge and control of the navigable streams of the interior it entered into a practical contract with the States and communities bordering these streams that their waterways would be improved to their highest capacity. The States were thereby prevented from improving the streams themselves. Corporate enterprise was forbidden to undertake the canalization of important stretches and fix the cost of their works and franchises on the traffic. The Federal Government has made its formal and deliberate declaration that it will do this work. That necessarily involves that it will make the improvements adequate to modern needs and possibilities. To do any less would be a mockery and breach of good faith.*"

DEFECTS OF THE SYSTEM.

How has the Government fulfilled this duty? Let the President in his courageous and forceful message answer. He says, as already quoted, that *no rivers of any other civilized country are so poorly developed as our own.* If we look for the reasons, outside of the great interests vested in the "rival" carriers which have found it simpler and cheaper to regulate legislation than to purchase and destroy canals, we will find that the complaint is made of the wholly inadequate appropriations for the rivers and harbors

of the country. Even to-day with the great enthusiasm and thorough organizations existing from Maine to Texas and the universal demand for relief, the policy of Congress is not to pass a bill, and thus the paralysis continues while tentative works are encouraged in isolated localities notwithstanding the strenuous efforts of the committees to secure continuous appropriations for the trunk lines of traffic, and even new works are authorized in inaccessible districts where there is no commerce because of the great dangers surrounding the approaches. But is this complaint well grounded?

LACK OF INITIATIVE AND OPPOSITION BY GOVERNMENT.

In the first place although, as Senator Knox has stated, the Government has assumed the jurisdiction of all waterways or those that may be made navigable, it does not take the initiative in originating their improvement, and it is left for the localities interested to send their committees to Washington, and in many cases to retain permanent solicitors at the capital to further their interests. Thus all sections are arrayed against one another and allied with other adverse interests, and because of the demands for large appropriations for less imperative departmental services, these vital works are postponed from time to time, amounting to generations, and without national aid or consent the localities are deterred from inaugurating improvements of their own.

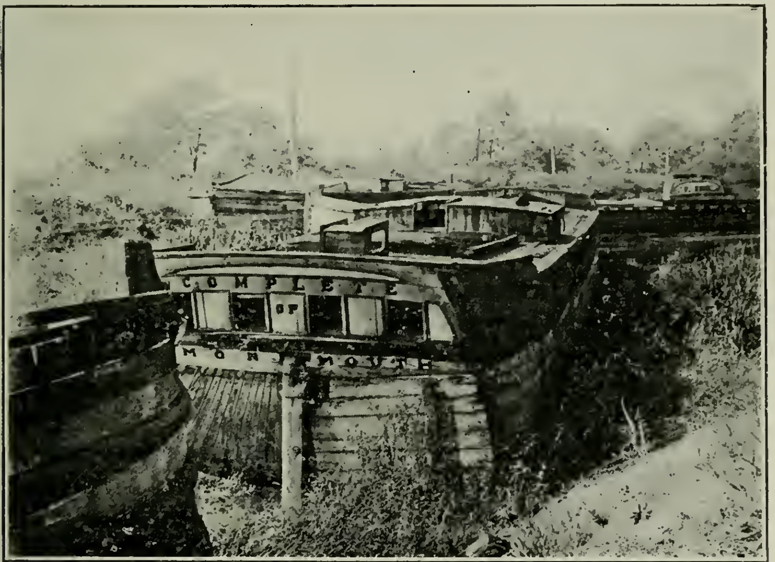
Not only was the Erie Canal thus opposed, but the Sault Ste Marie, the greatest portage on earth, was objected to in Congress as being "beyond the pale of civilization if not in the moon." Yet no expenditure made by the United States of equal amount has returned so vast a profit to its people or done more to promote their welfare.

The Louisville and Portland Canal was also opposed by the Government in the early part of the last century, and was finally started under a charter from the State of Kentucky issued in 1825, and built by a stock company, which subsequently released it to the United States at a large profit to the latter after earning $1,200,000 more than its entire cost.

The Delaware and Raritan, the Morris and Essex, the Schuylkill and Susquehanna, the James River and Kanawha, the Chesapeake and Ohio, and in fact practically all of the canals in the

country were built by private capital under State charters and without aid from the Government.

Since the advent of the railroad they have been purchased and exterminated to such an extent that less than fifty per cent. of the mileage has survived, and these are too small to meet the demands of modern traffic without a thorough reconstruction. Some of the wreckage of the Pennsylvania canals is shown in Fig. 1, and is indicated by the very name of the boat, which is "Complete."



APPROPRIATIONS AND RESULTS.

A brief digest of the expenditures of the Government upon our rivers and harbors will serve to throw some light upon the efficiency of these works, regardless of the abstraction of the traffic by the railways and the great increase in the dimensions of vessels which demand channels of much greater capacity.

Up to the beginning of 1867, the total expenditures by the Government for rivers and harbors was $14,994,206.63, and yet the canal and slack-water systems had been built and were well maintained, while, since that date, the expenditures for these improvements have aggregated $559,909, 090, and the results are charac-

terized by the Chief Executive as "largely negative." "No single agency has been responsible under the Congress for making the best use of our rivers, or for exercising forethought in their development. In the absence of a comprehensive plan, the only safe policy was one of repression and procrastination. * * * In spite of large appropriations for their improvement our rivers are less serviceable for inter-state commerce to-day than they were half a century ago, and in spite of the vast increase in our population and commerce they are on the whole less used."

This pregnant paragraph contains much food for thought since it is during this period of "repression and procrastination" that these works have been almost exclusively under the control of the War Department, whose officers are prohibited by virtue of their duties and training, as well as from their temporary details at various stations and the absence of individual responsibility for the plans, from inaugurating or recommending any project; while it not infrequently happens that they are responsible for the approval of the plans for the structures over or under navigable streams designed by the common carriers who desire to retain the tonnage by blocking the waterway, which purpose would seem to have been accomplished by the statement in the report of the Commission that among the reasons for the decline of river traffic was "the adverse placement of tracks and structures, and by various other means." This is confirmed by the fact that instances are numerous where permanent steel girders or stone bridges have been erected over waterways, presumably by authority of the War Department, at so low an elevation as to debar even coal barges from supplying mills and factories with their fuel, formerly received by water, and placed upon navigable streams because of that possibility.

This bureau, which has had control of the works and plans during all this time, is perhaps unfortunately the only one which can be held accountable for the present conditions of the waterways, and after so many years of management it may be of interest to hear what the Mississippi River Commission has to say with reference to the improvements of that great drainage and navigation system to which His Excellency refers, as having at one time no rival in any country for the traffic, which has to-day almost vanished from its surface.

In the official report for the year 1903, the Commission states:

"Systematic work, which has for its object to permanently locate and deepen the channel, has not been practicable under existing conditions. In the limited extension and repair of bank protection and contraction work the Commission has, however, kept in mind that the permanent improvement of the river is contemplated by the organic act, and experiments are continually being made looking to the best use of available material and the development of appliances and methods which may be economically and effectively employed when Congress shall provide for such systematic improvement." All of which appears to imply that notwithstanding the "large appropriations for their improvement," the Commission is still unable to show any definite results until Congress shall make them still greater. But it seems that the levee system has grown enormously in height, length and breadth, and that this irregular enceinte has not had any material effect in the improvement of the channel. On this point the distinguished and patriotic ex-Senator from Arkansas, Senator Berry, said: "Under the Constitution, Congress had no power to appropriate money to protect private property. I want to say to-day that every dollar that has ever been appropriated for levees on the Mississippi River has been on the theory that it would benefit navigation, and we never dared to put it on the ground, up to this day, that it would benefit private landowners, though we knew of course that it was incidental to it."

The statement was also made freely that the effect of this protection from overflow was to advance the value of the low swamp lands as well as the uplands "all over the alluvial valley, in some places 100 per cent., in some places 200 per cent., in some places 300 per cent.," thus showing the almost irresistible inducement for large appropriations from the national treasury and their application to the construction of the levees which produced negative results upon the navigability of the low-water stages and compelled the resort to hydraulic dredges to remove the additional mud thus confined to the bed of the valley and which formerly escaped to enrich the plains and reclaim its swamps.

That the policy of "repression and procrastination" is still prevalent, is also manifested in the rules adopted by Congress prohibiting appropriations prior to a survey, although it frequently happens that all necessary data are on file in the Government offices, but by this means the works can be forestalled, from two to three

years, and the funds be applied for other purposes while the country waits, or, it may be that in the absence of definite plans and the necessity for keeping up appearances or to exclude some proposition which may be guaranteed to give the requisite channels, which other interests may not desire, the appropriations may be recommended and the contracts let in such manner as to permit of changes of plans as the difficulties are developed during the process of the work. Under this policy the proposals of Capt. Jas. B. Eads, and others, for the improvement of Galveston Harbor, the Southwest Pass, the Aransas Pass, the mouth of the Columbia River, New York entrance and other important places were rejected and many of them suppressed from the official reports to Congress. The story of the delta of the Mississippi has almost reached a crisis. After Eads was remanded to the South Pass, which is no longer equal to the demands of the traffic of the great river, the Government engineers submitted a plan for the opening of the Southwest Pass, at an estimated cost of $13,-000,000 for two parallel, straight jetties. Congress was not very favorably impressed with it, since a large portion of this work was out of the water and on the marshy banks of the river, or else in deep holes of twenty or more feet, close beside the natural banks, so that a revision was ordered to meet the offer of responsible parties to create a thirty-five-foot channel, and guarantee the results, for $6,000,000.

A Board of Engineers abandoned the original plan and reported in favor of a bottle- or coffin-shaped arrangement of jetties, placed so far back from the river bed as "*to take from them the duty of forming the channel*" and placing the "*main reliance upon dredging.*" The results to be expected from this plan, with the enormous quantity of silt, amounting to over 100,000,000 cubic yards annually, which the Pass was carrying to the Gulf, was pointed out to the Board by the parties making the guaranteed proposal, but this merely resulted in a hasty modification of the location of the jetties and an appropriation for the construction on the proposed plan, of which it was stated in the report to Congress that "No contract for the superstructure should be made until experiment and experience have developed the most economical methods of construction." Also, "The construction engineer should be free, subject, of course, to the approval of the Chief of Engineers, to modify them (the plans) in all particulars, as experience may dictate."

Such were the conditions under which work was undertaken at the mouth of this sedimentary delta, with numerous precedents as a guide, and the main reliance was to be on dredging between jetties which had no duties to perform as channel formers. The work as to the jetties is now reported as completed and two hydraulic dredges have been constantly engaged in the efforts to cope with the sediment, with the result that the ruling depth is reported at twenty-two feet and the crest of the new bar is about a half-mile outside of the jetties, which have scoured a hole far deeper, between their outer portions, than was required for the channel, extending to over eighty feet, the material from which has been added to the bar beyond, and the jetties are now to be extended into the Gulf, thus flattening the slope of the river and increasing the heights of the floods and danger from crevasses.

Many such instances of tentative plans may be cited, but suffice it to point out one of a purely tidal entrance with a feeble diurnal tide upon which a Board reported in 1887 as follows:

"The problem of the improvement of the navigation of this pass (Aransas Pass, Texas) is by no means an easy one. Some of the difficulties may be mentioned, viz.: The want of stability in the position of the pass itself, which is constantly and rapidly moving under the influence of causes—winds, waves and currents—of which the action cannot be prevented and the effects only measurably neutralized; the instability of the foundations on which any structure is to be built; the shifting sand of the Texas coast, the presence in the water in which any structure must be placed of the sea-worm in such activity that wood cannot be used. except to a very limited and exceptional extent, if at all; the necessity of bringing stone, cement, etc., from long distances and at much expense; the heat and other discomforts of a tropical climate increasing the cost of labor." * * * "As the work progresses experience will probably suggest variations of detail. There is good prospect of success in deepening the channel by the use of the jetties. The location of those recommended (by the local engineer) is approved, subject to such change as further study may show to be expedient." * * * "No work should be begun unless there be on hand for expenditure a sum not less than $500,000."

Although this report was approved by the six members of the Board of Engineers, one of them dissented the next day and wrote

that he believed "one jetty would suffice at this locality," and that he "did not coincide with the views expressed in the report of the local engineer either in general application or in particular at this locality." It may be well to state that the local engineer had had but a limited experience in tidal waters prior to that date.

Under the above stated conditions and the tentative nature of the plan it would seem futile to even suggest a remedy in this case, and although the efforts made by the Government to secure even twelve feet had been a signal failure, yet subsequently private parties did submit a guaranteed proposition to create a twenty-foot channel for about one-fourth of the Government's estimate. This plan was finally taken over by Congress, as set forth in the

February number of the Franklin Institute *Journal,* and after many and serious delays and great opposition, completed in part, as shown in the illustration herein (Fig. 2), with the result of securing depths of over twenty feet along the completed portion. reaching even to twenty-six feet as a maximum, by the natural action of the currents and without dredging, yet, as shown, the Government has not permitted sufficient time to elapse for the currents to complete the channel, nor would it expend the petty sum of $6,000 to hasten the formation of the channel under the adverse conditions of an exceptional summer, but it has appropriated over a *million* dollars to return to the temporizing method of experimentation with two jetties to maintain an artificial chan-

nel to be created subsequently by dredging at an annual cost of $75,000. This is but another flagrant reason why the President seems to be fully justified in the statements he makes as to the necessities for reorganization and coöperation in the formulation of a systematic plan for the conduct and control of the waterways of this great federal domain.

THE "NO TOLL" FALLACY.

There is somewhere an idea prevailing which has been sedulously impressed upon the public mind that *all* waterways should be free.

This is true, however, only of certain public waterways built at public expense, but had this policy prevailed from the days of the independence of the United States, where would our waterways have been in the past, and if we are not to begin any project "until the funds necessary to complete it promptly are provided and no plan once under way should be changed except for grave reasons," how soon will our internal systems be opened? The experience of legislation in the past forty years will serve to show the utter impossibility of securing the appropriations or the plants which will meet the emergencies. The plans at Panama, exploited as thoroughly as ever any engineering work was or could be in the century of investigation, are being constantly changed to meet new conditions, especially those due to enlarged capacity of vessels, which were not foreseen. The prohibition of tolls must of necessity debar many of the minor but important local projects from being undertaken by States or localities and thus check the commercial streams at their sources and play into the hands of the very interests which have so long swayed the destiny of the country in regard to traffic by restricting the growth of the cheapest known means of transportation. In the humble opinion of the writer, this error of requiring all projects to be first approved by the general government and the prohibition of tolls as a legitimate return for the expenditures of private capital in the development of the resources of the nation, would be a most serious detriment to all interests, and a violation of the fundamental principle upon which all transportation companies are based, namely, the right to collect a reasonable compensation for moneys expended for services rendered the public, by private or local interests. Such in-

hibition would debar the States from their sovereign right to grant charters to such companies and deprive the States from their usufruct from any royalties or franchises which said States may see proper to authorize for the benefit of their own citizens, which rights and powers were distinctly reserved by "the people" in the framing of the Constitution, but they seem to have been "assumed by the Government," as stated by Senator Knox.

But it is well to reserve and exercise the right to limit the terms of such corporate powers and to provide means for emancipating the avenues of trade from the tolls, so soon as the originators may have been recouped for the outlay or the tolls become a burden in restraint of inter-state commerce. It may be germane to inquire whether the Panama Canal is to be exempt from tolls when completed, and if so, is the expenditure so largely in behalf of foreign nations justified while our domestic waterways are denied the vitalizing appropriations? Is the Suez Canal free? No. Why not? for it has paid for itself many times over.

In short, the system which would appear to furnish the most speedy relief would be approximately one which would confine the national appropriation to the trunk-line waterways for interstate commerce; such as applies to the great rivers, the lakes and the intercoastal systems, with the important harbors of the lakes and the seaboard and such canals as constitute necessary links in the great chain of internal communications, for which a liberal minimum of draught should be fixed and the works be placed under permanent, resident and division engineers, who should be held strictly accountable for results, as was outlined in the legislation as proposed in the Cullom-Breckinridge bills of 1886-7. These should be amended, however, to meet present exigencies and to eliminate the need of special legislation as far as possible in the inauguration and conduct of these works.

COMMISSIONS VS INDIVIDUAL RESPONSIBILITY.

During the inception of the plans and their evolution to a completed project a commission of experts may be of great value, especially where many subdivisions of science and art are involved; as hydraulics, sanitation, mechanics, electrics, organization, finance, administration, etc., yet these requisites are not always simultaneous but arise in sequence and after a general

project is well matured it would seem best to refer the details to some one or more responsible individuals to work out as the local exigencies may demand. Thus is avoided the generalization and shifting of responsibility which invariably accompanies the ever changing personnel of a Board composed of men whose succession in office or change of station necessitates rotation in duties, and lack of familiarity with details which are often vital, while experiments and changes of plan are expensive and frequently unnecessary, if the problem is well exploited in advance. Moreover, the removal of a competent official by reason of an age limitation at a time when his experience is most valuable is opposed to good policy.

The various isthmian canal commissions and the conflicting plans and estimates which they submitted will serve to illustrate the difficulty of securing the most direct results from a large body of experts, so that it has been found necessary to reduce the personnel until it is now a minimum, and the work is progressing rapidly under the admirable system which has been developed on the isthmus in the past few years.

It is true that there are many factors incidental to the development of navigable channels, such as the amount of rainfall, the rapidity with which the excess reaches the stream, the topography of the district, the extent of its forests, the character of its soils, its stratigraphy, the extent of its drainage basin, the obstacles which beset its discharge, the alignment of the path and the character of its outlets and tributaries. Some of these elements are so remotely connected with the mere question of capacity of channel for navigation that it would seem greatly to complicate the issue, to involve the prompt relief from obstructions, in a general consideration of all these collaterals. River regulation is one of canalization and preservation of uniformity of flow as well as of the abstraction of sediment from the bed, either by prevention at the intakes, relief at outlets, or removal and impounding *en route.*

These are questions pertaining to the profession of the civil and hydraulic engineer, the general principles of which are readily understood and applied, and what it immediately desired is not elaborate research into the intricate, complicated relations of trade or commerce by various media so much as the enabling legislation and release from the restrictions which have of late impeded the

free application of local resources to the creation of better transportation conditions. Even now contracts are being taken for vessels of 1,000 feet length and forty feet draught—yet there are few harbors in the world where such a steamer can berth beside the dock.

Judging from the results secured by the Bureaus of Irrigation and Forestry it would seem that the present organizations are working very effectively and harmoniously under their executive heads and that the work done tends incidentally to the conservation of both the water and sediment to keep the latter from the stream-bed and retard the flow of floods, for the benefit of navigation during low stages. The establishment of reservoirs for irrigation or for power will incidentally restrict the storm flow, as do the great Alpine lakes of Switzerland, and discharge the clarified effluent for navigation or for domestic or manufacturing purposes.

The question of the sale of the power thus stored within the States or territories, by the Government, is one which must be left for adjustment in future, but like many others of similar import, it can better afford to wait than can the more urgent, nay even vital one of the navigability of the streams.

OBSTACLES TO DEVELOPMENT.

From this brief review of the situation it appears that the main causes which have resulted in the decadence of the waterways of this nation and the traffic upon those that still remain in service are:

1. The growth of railways and the attempts of legislators to tax their tonnage in support of their competitors, the canals, previously chartered.

2. This led to reprisals to exterminate the waterways, resulting in the focussing of their control in a single legislative body at the national capital where the situation could be more readily handled and where the river and harbor, as well as many other bills, were made subordinate to the policy of the regnant administration under the Committee of Rules, which in turn is appointed by the Speaker. A consequence of this mechanism was a delay in the opening of a canals across the isthmus of Darien for nearly a century after the first American company had been chartered

for the purpose. Also the postponement of work upon the Hennepin and other canals for many years, as well as the delays in the improvement of the Ohio, Mississippi, and other rivers, because of the pressure from antagonistic interests, which could be so readily applied, to defeat legislation, on the pretext of economy or more urgent use of funds.

3. These forces were also allied to local and sectional jealousy which demanded an equal share in the distribution of the public patronage, as a consideration for approval, and hence the admissions frequently made that the small appropriations for isolated improvements were necessary to secure the passage of the bills.

4. A fourth cause is the fact that the Government does not take the initiative in making any improvements and often goes so far as to oppose the inauguration of much needed new work and of prohibiting localities from undertaking it at their own expense. In fact, one of the officers of the Corps of Engineers made the significant statement as to the reason for lack of progress that "We are forbidden, and properly so, from urging appropriations for new works, and are limited solely to giving our views and estimates, when asked to do so, by the proper authority."

One may well wonder how soon all the work of this great country, with its extended insular possessions, would be improved if the head of the Department at Washington must first initiate an inquiry as to what may happen to be needed in some remote part of the federal domain and the report must be transmitted through a succession of local officers and Boards, for examination, report, and final approval by a single individual before even an appropriation may be requested from the national treasury for a survey, while the local interests, if not restricted, would have successfully completed the work in many cases at their own cost, pending this circumlocution. Neither the Erie Canal nor the Sanitary District Canal of Chicago would have been built but for the State initiative, and many other States are to-day organizing improvement associations for the immediate completion within their borders of their own lines of traffic by water, by reason of their necessities.

5. Another cause may be found in the onerous conditions attending the execution of Government contracts, which make it difficult to find the sureties required and which have caused the failure of such guarantors from the arbitrary interpretations

imposed by incompetent inspectors placed upon the works and whose orders are absolute, which conditions add largely to the cost of Government works and thus tend to limit the benefits and extent of the appropriations.

6. The policy of rejecting or suppressing thoroughly guaranteed proposals for the opening of rivers and harbors under bonds for the successful completion of the works and for payments to be made only as the channels are obtained, is believed to be another serious cause for the absence of greater depths which could be secured by the use of the energy stored in currents of the rivers or in the tides of the seas.

None of the above causes are physical, but they are incidental to legislation, and as soon as our legislators and others can see their way to adjust them so as to open the door to a general movement for work all along the line, just so soon will the facilities begin to be provided on a scale commensurate with the needs of a great and industrious nation.

TWO SIDES TO "CÖOPERATION."

The proposition to cöoperate with interests not now aggressively taking part in these improvements is an excellent and desirable one, but it has been sadly perverted. In former times, under the old régime, it was the Government that occasionally cöoperated with the States by contributing to some of the works undertaken under their charters and thus becoming a partner in the corporations thus organized, as in the case of the Chesapeake and Delaware Canal Company, in which the United States is still a shareholder; but in more recent days the tables are turned, and cöoperation appears to mean a contribution from the locality desiring improvements to the extent of large appropriations made to the Treasury of the United States to induce it to inaugurate the necessary improvements, and yet even this is not always effective in securing even a survey for deeper channels, although the entire expense thereof may be borne by the locality. This is the kind of cöoperation which places all the funds and all control in the hands of the centralized authority without producing the desired relief and is not such as would improve the situation physically.

It will be many years before the physical data and the various conditions affecting our economic resources can be collected and

thoroughly digested and formulated, by which time the growth of the population and its productivity will have again modified extensively the then existing conditions so that it would appear to be of great importance to frame some general legislation as a basis for the general development of navigable channels at the earliest moment and make provision for a permanent and radical policy of conducting our public civil works if this generation is to derive any benefit from the movement.

In the Preliminary Report as submitted, although signed by all the members, it appears that there were dissenting views as to how its findings should be rendered effective, and the appendix submitted by Senator Newlands, the earnest and successful advocate of the irrigation and reclamation projects, are so pertinent that they deserve the attention of all good citizens, interested in the welfare of the nation. What the Senator says in his supplementary report is this:

"I desire to emphasize my belief that it is of the highest importance that in dealing with subjects relating to the respective powers, rights and interests of the Nation, States, municipalities, corporations and individuals, large powers and a comparatively free hand should be given to an administrative body of experts in the full development of projects, lest the complexity of the transactions, the time necessary to secure Congressional approval, and the difference of view as to purpose or method, may result in indecision and delay, the worst enemies of effective development.

"An ample fund should be provided, to be reinforced from time to time either by the legislative appropriation or by bond issue, and the administrative board or commission should be given power, not only to investigate projects, but also, when determined to be feasible, to enter, with the approval of the President, upon their immediate execution; but the power should be limited so as to prevent such administrative body from entering into any contract unless there are sufficient moneys in the fund to meet the cost thereof.

"Unless some method of construction and development, insuring prompt decision and execution and continuous and consecutive work by a body of experts is adopted, I fear that the best of projects may be wrecked in the shoals and quicksands of legislation."

This fear has been confirmed by past experience, time and

again, and it would seem to meet the situation fully to adopt the policy of awarding contracts to any responsible parties who may volunteer to bid upon a guaranty of payments for results secured within reasonable time limts, in which case no risk is taken by the Government and there is an immediate return for the moneys expended. In the few instances where this policy has been tried, the results were eminently satisfactory, but the precedents were not followed by Congress because of the opposition of the "system."

MAKING AN ARTESIAN WELL PUMP ITSELF.

The field men of the United States Geological Survey, in their investigations of the ground-water resources of the Virginia Coastal Plain, have observed that the flows from any artesian wells in that region are utilized to drive hydraulic rams for the purpose of lifting the water to higher levels. Along the lower courses of the Potomac and Rappahannock and along the shores of the many inlets that run back from Chesapeake Bay above the James, there are hundreds of artesian wells that supply a perennial flow of beautiful clear water which is, as a rule, excellently adapted to all domestic uses and is largely utilized by the canning factories and other industrial establishments that abound in that part of the country. Though the pressure of the water from the wells is ample at the shore level, the head diminishes so quickly with increase in elevation that no flow can be obtained along the higher banks above the shore, where the water is most needed. The common method of obtaining it at these higher levels is to use the force developed by the artesian flow to operate hydraulic rams, which in turn raise the water to the heights desired along the bluffs above the rivers and inlets. Thus it may be said that the artesian wells pump themselves.

TOPOGRAPHIC WORK IN NEW YORK.

The United States Geological Survey announces the completion of plans for topographic work in New York, which is performed under cöoperative agreement with the State Engineer and Surveyor.

Under these plans the mapping of the Cooperstown and Delhi quadrangles will be brought to completion, and secondary control will be carried over the Neversink, Monticello, Bath, and Stony Creek quadrangles. The work on the first four of these quadrangles has been assigned to C. E. Cooke, who is assisted by W. H. S. Morey, but assignments for the Bath and Stony Creek quadrangles have not yet been made.

The expense of the field work is shared equally by the State and Federal Survey.

Saving the Forests and Streams of the United States.*

By Dr. Thomas E. Will,

Secretary of the American Forestry Association.

We have thought of our natural resources as inexhaustible. Observation and experience are teaching us our mistake. Says a nameless writer in the *Commercial West*:

"The discoverers of America found themselves chin deep in a reservoir of rich natural resources. Your grandfather was in it up to his shoulders. Your father waded around waist deep in God's reserve of material mercy. You are standing in it knee deep. Your boy will find some of the rich original mud on his shoe soles, and your grand son will be raking over the dump for some of the old, abandoned scraps of the gone-by Golden Age. It will be but about five hundred years from the discovery of America to the final looting of her fat inheritance."

Among the resources thus destroyed, the forests are one of the most important. Former Judge Howland, President of the Association for the Protection of the Adirondacks, is authority for the statement, that on Sunday, March 25, 1903, a New York paper, circulating some 800,000 copies, consisted of eighty pages. "This single edition," he said, "required the product of 9,779 trees sixty feet high and ten inches in diameter at breast height, which, if planted forty feet apart, would represent a forest area of 351.8 acres."

In the United States were once four great forest areas, those respectively of New England, the Great Lake region, the Northwest and the South. Of these, the first two are largely gone, and the third and fourth are disappearing with bewildering speed.

*A lecture before the Franklin Institute, Friday evening, November 1, 1907.

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Black walnut (Juglans nigra), Harlan County, Kentucky

The question of conserving what remains of the forests of the Northwest and the South and of renewing our denuded forest areas, is one of foremost importance to the people of the United States.

The hardwood question is, of itself, of vast import. American hardwoods once lay in four regions: Those of the Great Lakes, the Ohio Valley, the lower Mississippi and the Southern Appalachians. Of these, the first three are largely gone and the chief reliance of the American people for hardwood is now upon the Southern Appalachian area. This fact alone renders the Appalachian Mountain forest question national.

What would the loss of our hardwoods signify? Take an illustration. The business man spends the day before a desk of solid sand-stone; in the evening, he adjusts his toilet before a concrete dresser, joins his family around a cement dining table, enters next with them his library; hands his wife a sheet-iron rocking chair, stretches himself upon a chilled steel sofa and proceeds to spend the evening listening to his daughter discourse music, more or less sweet, from a cast-iron piano.

Many forces are coöperating to destroy our forests. Windstorms and insect pests commit ravages. Unrestricted grazing, notably by sheep, destroys the young growth and prevents reproduction. Man and fire are the chief agencies of destruction. The attempt to cultivate forested mountain slopes leads to clearing, and to exhaustion of the soil, and leaves areas of desolation on the mountain sides. The old-fashioned boxing method of turpentining is wasteful. With modern methods, the lumbermen harvest our forests as Dakota farmers harvest great fields of wheat, but with this difference: the farmer plans for future crops; the lumberman plans but for one. With him, it is once and out.

Our normal consumption of wood is prodigious. We use annually enough lumber to floor the state of Delaware, enough shingles to shingle the District of Columbia, enough laths to load a railroad train extending from Boston to Ohio, enough tight cooperage stock to build a rick four feet wide, four feet high and reaching from New York City to Colorado; enough fire wood to make a wood pile a half mile wide, a half mile deep and a half mile high; enough railway ties to build a railway extending round the world and back across the Atlantic, and the amount of our annual wood bill exceeds a billion dollars.

But to the use we must add the waste. The figures are appalling. We leave more than half the crop in the woods as kindling for forest fires. The rapidity with which we have burned up our forests is inconceivable. The forest fires of 1871 destroyed more

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Caspar, Mendocino County, Cal. Yarding donkey and yarding crew. Turn about to be hauled out by bull donkey.

property than the Chicago fire, and the fires of 1881 were still more destructive. Outside our National Forests the besom of destruction still sweeps on.

Said Dr. B. E. Fernow: "It has been officially estimated that forest fires in the United States destroy annually about $50,000,000 of standing timber and burn over an area of at least 15,000,000 acres. In twenty-eight States, the area burned over in one year was pretty accurately estimated at about 7,789,734 acres, and the loss close to $24,000,000."

How long will our stock last at this rate? Nobody knows exactly. It is hoped that a timber census will be taken through the coöperation of the Forest Service and the United States Census that the facts may be made available. We are certainly using up

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our wood three times as fast as we are producing it. Under present policies, two or three decades will surely see the finish of our forest heritage. Were this period twice as long, in the life of a nation it would be but the infinitesimal fraction of the diameter of a hair. Already the shadow of the timber famine is upon the land. What this may mean we may learn from China, whose forests were long since destroyed. A recent newspaper cartoon picturing the ruin of American cities and showing the transportation, by caravans of camels, of corn through the desert of Iowa to Chicago, is suggestive.

Says Mr. Gifford Pinchot, Forester of the United States Department of Agriculture:

"Under present policies of use and waste, the timber supply of the United States will last probably from twenty to thirty-three years.

"When the forests fail, the lumber business, now the fourth greatest industry in the country, will, of course, disappear. Suffering among all building industries will immediately follow. Mining will become greatly more expensive; then naturally the price of coal, iron, and all other minerals will rise; by this the railroads will be directly affected and the cost of transportation and water power for lighting, manufacturing and transportation will immediately increase. All goods made from products of the mines will increase in price, which will hamper, not only agriculture, but the cost of production generally. In fine, when the forests fail, every man, woman and child in the United States will feel the pinch. And through misuse the forests are failing rapidly."

More important, probably, than the wood question, is the water question. Consider this question with especial reference to the East and South.

Practically all the important rivers of the South, east of the Mississippi, whether flowing into the Atlantic, the Gulf, or the Ohio system, rise in the Southern Appalachian Mountains. Likewise, practically all the important rivers of New England rise in the White Mountains.

For agricultural purposes, these rivers are indispensable. For navigation, their possibilities are great. In manufacturing, furthermore, these possibilities are being realized.

Since 1812, New England has been a great manufacturing section. Since 1890, the South also has been striding toward the front as a manufacturing section. As the cotton-gin typified the old-time, agricultural, slave-holding South, so the cotton-mill typifies the new, industrial, manufacturing South.

Mills and factories to-day are coming to be driven less and less by steam, generated from coal, and more and more by water, either applied directly or employed in generating electricity, which itself drives the machinery. In either case this water comes from the rivers which rise in the mountains. Its value is absolutely dependent upon its equable flow. A stream which pours forth

floods at certain seasons, and runs dry in others, is worthless and worse for manufacturing purposes. One prime problem with the manufacturer is how to maintain an even flow of the stream the year round.

To this end forests on the slopes in which the streams rise are of incalculable importance. Falling upon a densely forested slope the force of the rain is broken, preventing erosion. The water falls gently upon the forest floor where, to the point of saturation, it is absorbed by the forest mulch or carpet of leaves, branches and decayed vegetable matter, and passed slowly into the porous earth. Here it enters the underground circulation and, through days and weeks, passes slowly downward, emerging, in time, from springs to feed the rivulets and rills which, in turn, supply the streams, water the fields, carry the commerce and drive the wheels of mills and factories.

But let this mountain slope be swept by ax and fire. Often the bare rocks alone remain. Nothing now intervenes to check erosion or to absorb the rainfall and pass it into the underground circulation. Instead, like the Gadarene swine, it rushes violently down the steep place, carrying before it silt, sand, boulders, débris, whatever may be movable, depositing this in the streams.

Note the two-fold phenomenon. The water enters the streams suddenly, rather than gradually, and finds the channels largely filled with foreign matter. Inevitably, there follows the overflow and the flood. In a single year (1901-02) in a single section of the South, floods destroyed eighteen million dollars' worth of property. The Ohio River floods of last Spring are still remembered.

Observe some of the consequences: Rich, alluvial soil is swept from fields where it is indispensable, into rivers and harbors, where it is an expensive nuisance. In two or three decades river bottom farms, once worth one hundred to two hundred dollars per acre, have been made worth less than ten dollars per acre, or destroyed. The good roads movement has been counterbalanced by a bad roads movement. Railroads, culverts, and railroad bridges are continuously washed out and swept away, impeding traffic and transportation and destroying necessary capital. At Spartanburg, S. C., the Pacolet flood of 1903 absolutely destroyed two great cotton mills of one company and seriously damaged or

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Looking up Ellijay creek towards the Cowee mountains, showing wash and abandoned slopes in right and old fields reset in young hardwoods. Macon County, North Carolina.

Hillside erosion in abandoned fields. Catawba County, North Carolina.

destroyed many others in the neighborhood. This flood is traced largely to deforestation of slopes.

Says Mr. Charles A. Stone, of the firm of Stone & Webster, Electrical Engineers, Boston, Mass.:

"One of the most important features in the commercial development of a water-power enterprise is the uniformity of flow of the stream on which the development is undertaken. Where streams are subject to severe droughts or great floods, commercial development is practically impossible. Nature has provided for the uniformity of flow by covering the water-sheds at the headwaters of these streams with forests. * * * When these forests are cut off, conditions are entirely changed, and great freshets result."

Mr. Theophilus Parsons, a representative of the manufacturing interests of New England, says:

"New England is largely dependent upon her factories run by water-power. The flow of the rivers furnishing this power is growing yearly more uncertain. Both floods and droughts are more frequent. It is plenty or famine. This situation is due to the pernicious cutting of woods along the headwaters of the New England rivers.

"I have known the Connecticut for over thirty-six years. It drains an area of four thousand square miles. Until recently the wooded hills kept the flow of the river even. Now, in the spring, we have floods, while in the summer the water sometimes will not run our mills.

"This is a question in which every manufacturer on the eastern coast of the United States is interested."

In addressing the Committee on Agriculture of the House of Representatives on April 25, 1906, Mr. E. S. Watson, Agricultural Commissioner of South Carolina, testified that his State had something like $82,000,000 invested in cotton mills, which was constantly menaced by deforestation in mountains. He stated that some four and one-half million dollars were lost by the Pacolet flood. Sometimes as many as fourteen houses were washed away in a single night. Repeatedly he had seen whole sections of railway trestle which had been carried nearly 150 miles and landed in a fine plantation.

Such experiences are not new nor confined to the United States. China's great river, the Hoang-ho, is known as the "River of Sorrows." The frightful devastation and destruction

resulting from its repeated floods is well known. Scientific investigators trace these floods directly to the destruction of China's forests. To the same source they attribute, in a large measure, the awful famines which visit and revisit that unhappy land.

Mr. Bailey Willis, of the United States Geological Survey and the Carnegie Institute, said of China, in which country he had traveled:

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Railroad embankment on the Southern railway washed away in the freshet of May 21, 1902. When the embankment broke a large hole, more than 20 ft. deep, was washed out. This is where the pool is. An attempt was made to rebuild the road by a trestle, but it was found that the pool was too deep for a trestle to be built, so that a temporary road, shown on the left, was constructed around the pool. Greenlees, McDowell County, North Carolina.

"Large areas of Northern China have been rendered uninhabitable in consequence of deforestation, the hills being reduced to rocky skeletons and the valleys being filled with a coarse sand and gravel.

"Throughout Northern China the floods which have caused the Yellow River to receive the name 'The Grief of China,' are an immediate result of the deforested condition of the hills and the consequent rapid run-off of the spring and summer rains.

"The conditions resulting from deforestation cited in the two preceding statements add greatly to the severity of famines, since they very greatly reduce the productive area and occasion the failure of crops in flooded regions."

"The lingering tragedies," says the *Century Magazine,* editorially, "of those Mediterranean countries—Greece, Italy, France, Spain, and the African Coast—which permitted wholesale destruction of their forests, have been rehearsed for our warning,

> Till old Experience do attain
> To something of prophetic strain."

The stories of Dalmatia, the Karst, Asia-Minor, Syria and Palestine are startling. Says Mr. George P. Marsh, in "The Earth as Modified by Human Action:"

"We know that the clearing of the woods has in some cases produced, within two or three generations, effects as blasting as those generally ascribed to geological convulsions, and has laid waste the face of the earth more hopelessly than if it had been buried by a current of lava or a shower of volcanic sand." (P. 261.) "To the torrents (occasioned by deforestation) igneous rocks are as wheat to the mill stones * * * The fury of the waters and of the wind which accompanies them in the floods of the French-Alpine torrents is such, that large blocks of stone are hurled out of the bed of the stream to the height of twelve or thirteen feet." (P. 265.)

Landslides have followed deforestation. One, on September 4, 1618, buried to a depth of seventy feet, the town of Plurs, in the Valley of the Maira. Another on September 2, 1806, destroyed the town of Goldau, Switzerland, and four hundred and fifty people. Instances might be multiplied.

Following her revolution of 1789, France destroyed her forests at an unprecedented rate. Soon she began experiencing the effects already described; overflows, floods, devastation. Like us, ignoring causes and striking simply at effects, she began dredging out her streams and harbors. But in vain, for fresh deposits of silt and sand followed close on the heels of the dredgers. At last, ascending the streams, the engineers discovered the cause: the downward sweep of eroded matter from deforested mountain slopes. Then came the gradual and expensive application of the remedy; the purchase by Government of

mountain sides, the erection of barriers of wood or stone to hold back the earth flood, and then the gradual reforestation of the slopes from which the forests should never have been removed.

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Stalesboro, Ga. Cutting box. Long leaf pine near Ocilla. Georgia.

Said the United States Senate in its report No. 2537, on April 11, 1906:

"France began a work of reforesting denuded mountains in 1860, to repair, so far as possible, the damage which had followed the clearing of the forests under private ownership. By

1900 she had spent over $15,000,000 and acquired over 400,000 acres of land in this work, while annual expenditures were still going on at a rate of over $600,000 a year, and it was estimated that in the completing of the work the further purchase of over 425,000 acres of land and the additional expenditure of over $20,000,000 would be required. Owing chiefly to the necessity of acquiring for protective purposes deforested land, almost one-fourth of the State-owned forest in France must be nonproductive for many years."

We are repeating the experience of France in expending millions to remove from stream-beds and harbors deposits which forests would have retained on our mountain sides. Has not the time come when, instead of dallying ineffectually and expensively with results, we should attack causes themselves?

Happily, we have already begun this work. On March 3, 1891, Congress authorized the President to proclaim National Forest Reserves on the public domain. In consequence, we now have a National Forest area equal to all the States of the Union east of Ohio and north of North Carolina. On this, the United States Government, through the Forest Service of the Department of Agriculture, is actually solving the problem of forests and streams; *i. e.*, it is applying the principles of forestry to the management of our nationally owned and administered forests.

Do the principles of forestry forbid cutting? By no means. They require cutting. The scientific forester regards a forest as a scientific and practical farmer regards a field, namely, as a continuous source of wealth. The forest, like the field, if rightly handled may be used in perpetuity. Trees fit to be cut are cut; those needful to be saved to perpetuate the forest conditions,—cover, floor and what not,—and to ensure reproduction, are carefully preserved. Furthermore, the brush resulting from cutting, instead of being left scattered over the ground as food for a forest conflagration, is piled and burned under careful supervision. Thus, while its product is used, the forest, as such, is saved.

The fire problem receives careful attention. By means of fire lines and trails the forest is laid out into areas of convenient size, that fires may be segregated. Daily, during the danger season, the forest rangers, from some eminence, inspect the areas entrusted to their care. The sight of a suspicious looking smoke means prompt investigation. Should fire be found, the force is at once

called out and, if necessary, supported by outsiders hired, and even drafted, for the occasion. The fire is attacked with a vigor worthy of a fire department.

And with what effect? The National Forests have been in charge of the Forest Service less than three years. In that brief time the forest fire problem on the National Forest area has been practically solved and fire damage reduced to a negligible quantity. This victory alone would have abundantly justified the en-

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Biltmore, North Carolina. Reproduction of Loblolly pine.

trance of the National Government upon the work of forest administration.

Planting, however, has also been begun. In Forest Service nurseries seedlings are produced to be transplanted to the sand-hill deserts of Nebraska and Kansas, or to denuded mountain slopes farther west.

That economy may be wisely practiced, the Forest Service is also testing timbers to ascertain their relative strength, and is furnishing the resultant data to wood users. To facilitate sub-

stitution of inferior wood for superior wood, so rapidly disappearing, timber treating is being developed. For example, on abandoned fields of the South there springs up a tree, abundant as the weed and almost as lightly esteemed, known as old-field, or loblolly pine. Experiment shows that, after a practical, simple, and but moderately expensive treatment with creosote, this hitherto despised but abundant wood becomes as valuable as untreated oak and hickory. The possibilities of such a discovery are vast.

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General view of chaparral covered foothills. To be used in panoramic view showing fire line San Bernardino National forest, near Skyland, California.

The Forest Service is engaged in numerous other lines of helpful work.

Especial attention is called to the fact that the chief contribution to the solution of the problem of forests and streams is being made by the National Government on the National Forests. These forests, however, are all in the West. Practically all of them are west of the hundredth meridian. The reason is not that National Forests are needed in the far West more than elsewhere; it is, instead, that the law of 1891 authorized the establishment of such forests by presidential proclamation and on the public do-

main. Comparatively little public domain is found elsewhere. The bulk of the population and business of the United States however lies east of the National Forests.

Such forests are imperatively needed elsewhere, notably in the Southern Appalachian and White Mountains. Here, however, they can be secured only by Congressional action. The Appalachian-White Mountain Bill, providing for the establishment of these forests, has twice passed the Senate, was twice recommended for passage by the House Committee on Agriculture, was twice recommended by President McKinley through special messages, and once, in like manner, by President Roosevelt. Thus far, however, the House of Representatives, though understood to be favorable, has never found opportunity to vote on the bill. It is earnestly hoped that this opportunity will come to that body at the present session.

In 1899, Congress was first memorialized to establish the Southern Appalachian National Forests. At that time the National Government had opportunity to purchase one and one-half million acres of cheap, forest-covered mountain land at a price averaging $2.50 per acre, including the timber. To-day, the same land could not be procured for an average of $10 per acre. Had Congress, in 1899, acted promptly upon the memorial then presented to it, it would have gained from twelve million to fifteen million dollars in the mere price of this land, to say nothing of the vast economies which would have been effected through the prevention of wasteful cutting, fires, floods, and other evils consequent upon forest destruction. Like the Sibylline Books, the price of this land must continue to rise, and every day's delay must add both to the waste and to the expense which must be incurred by the Nation when the inevitable purchase comes.

Important as is the economic side of this question, there is another side equally or more important. It is that of the public health. Our people work too much and rest too little. Too largely are they confined in great cities, subject to an intense industrial pressure, cut off from access to the fields and woods, and deprived of the culture which comes with fellowship with Nature. The tendency toward exclusive city life should be counteracted. Increasing opportunity should be afforded our people, old and young, to visit the forests and streams, to rest their wearied bodies and recuperate their shattered nerves and fit themselves for larger,

completer living. To this end, our mountain forests are essential. Said the United States Senate, in its report above quoted:

"The White Mountains and the Southern Appalachians are alike in being natural recreation grounds for a very large part of our population. Over 60,000,000 of the people of the United States are within twenty-four hours of the Southern Appalachians, and the White Mountains have long held a foremost place as a summer resort, especially for the Northern and Middle Atlantic States. Both of these regions should be guarded and handed down to the generations which follow. They are great natural blessings with which we have been endowed and which we must protect."

This doctrine is eminently sane and wholesome. But to live up to it, we must stop the destruction now in progress in the forests of our eastern mountains; and in no way can this be done but by such action of the National Government as is contemplated in the Appalachian-White Mountain Bill.

THE STEEL RAILROAD TIE.

In view of the great interest taken in the action of the Pennsylvania Railroad Company in ordering the steel ties in its tracks at Mineral Point. Pa., to be replaced with wooden ones, the following communication from the chief engineer, A. C. Shand, to the *Railroad Gazette*, is highly important;

"Relative to the report made of the recent accident to train No. 29 on the Pennsylvania Railroad in the vicinity of Mineral Point, full copy of which appeared in your issue of Friday, March 1, 1907, I think you have written a very fair and creditable editorial on the subject, including not only the Pennsylvania Railroad accident but the accident on the New York Central, which occurred recently. The general impression seems to prevail, however, in nearly all the papers which have been brought to my observation that the steel cross ties for railroad track purposes are a failure.

"I would be greatly obliged if you would call the attention of your readers to the fact that, after most careful observation and study of the subject, I am more than ever impressed with the necessity in the near future of a substitute for wooden cross ties, and so far no material has been offered as a substitute that will meet the requirements except metal. I think, however, that all ties tested are a little lighter than they should be, and am firmly of the opinion that none of the fastenings for holding the rail in position to the tie is adequate to the requirements. This was emphasized in the accident we had, above referred to. When any suitable fastening shall have been designed, and there is no doubt in my mind that it will be in the near future, either by the Carnegie Steel Company or by some one else, I have not the slightest doubt that the experiments in con-

nection with the steel ties will go forward, not only on this system but on other leading railroads.

"On the Pennsylvania Railroad alone we are using about 4,000,000 cross ties a year, and with the increased price of cross ties in the last five years, and the difficulty in purchasing even at the increased price, it is obvious that some substitute must be secured before long. The quality of the timber also has depreciated enormously in the last five years, so that it becomes imperative that we should either purchase the best cross ties that the market affords and creosote these ties and use heavy tie plates, or secure a steel cross tie or one of some other composition which will answer the requirements. This company a number of years ago laid four sections of track with the steel tie as used at the time by some of the English railroads. These were of the inverted trough design, but did not give satisfactory results.

"What I am afraid of is that the general public, and the engineering profession in particular, will dismiss the subject of steel ties as a failure, when in reality they must come sooner or later, and the more intelligent thought given to this matter the sooner a suitable tie will be furnished which will be satisfactory in every particular."

This utterance from one who occupies so high an official position, and therefore fully appreciates the importance attached to whatever he may say, should set at rest the popular belief that the Pennsylvania Railroad Company has placed the seal of its condemnation on the steel tie. The manufacture of steel ties is one which has in it the promise of great possibilities, and the entire steel trade is therefore deeply interested in anything which may develop regarding it. There is no doubt that the ingenuity of American manufacturers will be successfully applied to the production of a steel tie which will fully meet the requirements of railroad engineers.

FIRST INTERNATIONAL CONGRESS FOR THE ADAPTATION OF ROADS TO MODERN TRAFFIC, 1908.

Preliminary announcement is made by order of the Minister of Public Works of France of the meeting of the First International Congress for the Adaptation of Roads to Modern Traffic, which will be held in Paris late in the year 1908.

The object of the Congress is to ascertain what has been accomplished in road engineering in various parts of the world.

The extensive use of automobiles in France has brought out the fact that the macadam road is no longer suitable for highways. Both from a hygienic and engineering point of view it is no longer desirable, and the French Government will endeavor to ascertain whether roads of the future shall be made of asphalt or some other material, and whether tarring, which has been tried with a degree of success, will solve the problem of the disposal of dust and mud.

In connection with the Congress there will be held the First International Exhibition of Machinery used for the construction, maintenance and cleaning of streets and roads.

(Stated meeting held Wednesday, February 19, 1908.)

A New Radiation Pyrometer.

By Charles Burton Thwing, Ph.D.

The instrument to be described is the outcome of an attempt to produce an accurate means of measuring the higher temperatures used in ceramic and metallurgical operations which should be at once simple, portable and direct reading, so as to make possible the quick and accurate determination of high temperatures by ordinary workmen.

The principle employed is the measurement of the total energy of radiation by means of the current generated in a sensitive thermo-couple by the radiations concentrated upon it. The principle has already been employed by Féry in his "Pyrometric Telescope."

The novel features of the new pyrometer relate both to the means employed for concentrating the radiations and to the design of the galvanometer used for measuring the current generated in the thermo-couple.

The Stefan-Boltzmann Radiation Law may be stated as follows: The energy radiated by a black body is proportional to the fourth power of the absolute temperature, or

$$E = K\,(T_c^4 - T^4).$$

where E is the total energy radiated by a body of absolute temperature T° to a body of absolute temperature T_o°, and K is a constant depending on the units used.

The validity of this law is unquestioned. The conditions furnished by a black body are closely realized by such substances as clay and porcelain and by iron and other metals in the solid state as well as by any body whatever which is contained in an enclosure

having a small opening only. The departure of molten iron and copper from the conditions of a "black body" will be referred to toward the close of this paper.

It is highly desirable for rapid work that the Receiving Tube of the pyrometer should be so designed as to be independent of the distance of the hot body from the tube, so as to avoid the loss of time required for focusing and to eliminate the possible error due to inaccurate focusing. This end has been attained in the pyrometer under consideration by the use of a conical mirror for concentrating the radiations. It is evident from a consideration of Figure 1 that, since the containing tube is dead black, no radiations reach the conical mirror from any part of the observed surface outside the solid angle A O A′ and all radiations from the surface falling within this angle are transmitted by multiple reflection to the thermo- couple at the small end of the cone. If, for example,

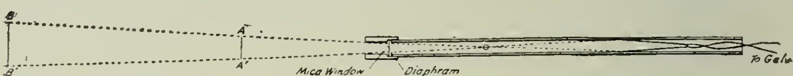


Fig. 1. Diagram showing why the readings of Thwing's radiation pyrometer are independent of distance from the object.

the energy, E, received from a surface of area S at a distance $\overline{OA}$ be compared with the energy, E′, received from the larger portion of the same surface S′ subtended when the distance is $\overline{OB} = 2\ \overline{OA}$ it will be seen that,

$$\frac{E}{E'} = \frac{S/\overline{OA}}{4S/4\overline{OA}} \text{ or, } E = E'$$

since the area increases with the square of the distance and the intensity varies inversely with the square of the distance.

In practice the indications are found to be thus independent of distance, the one condition being of course fulfilled, that the surface is of sufficient area to fill the solid angle OBB′.

In the portable form of pyrometer the Receiving Tube is about 70 cm. long and 25 cm. in diameter. In the stationary type the tube is made shorter and is shielded from the disturbing effect of local temperature variations by a jacket containing water or oil.

It is found desirable in most cases to point at the inner wall of a tube of fireclay or iron which projects into the furnace far enough to take the temperature of the surrounding gases without

permitting the ingress of cold air to the furnace. Suitable leads conduct the current generated by the radiations from the thermo-couple to the indicating or recording galvanometer, as shown in Fig. 2.

It is important that the galvanometer used with the portable receiving tube should be of a form which does not require leveling and at the same time sufficiently sensitive to respond to the small

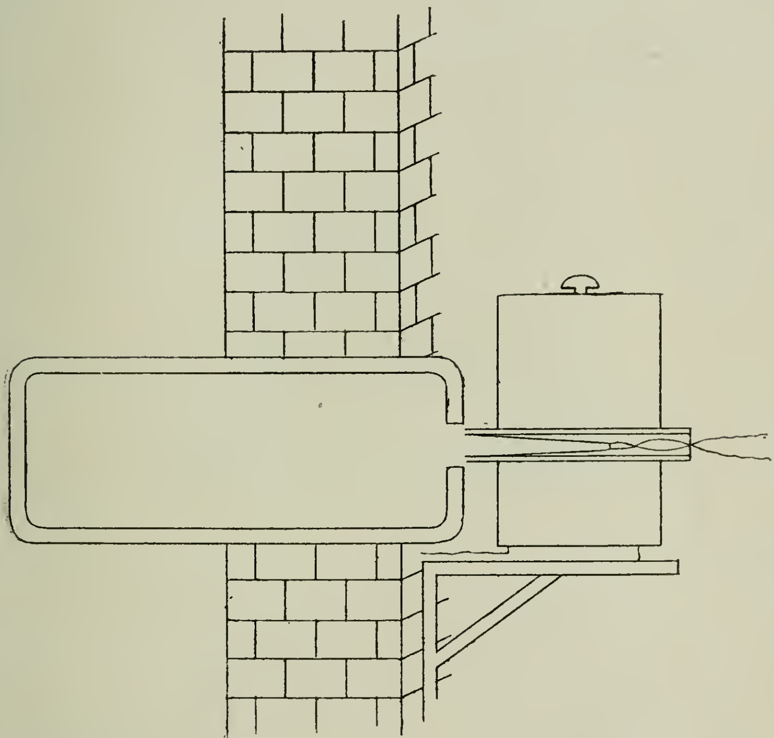


Fig. 2. Showing water jacketed receiving tube in position for continuous record.

current generated in the thermo-couple by a difference of temperature never exceeding 150 degrees Centigrade. As ordinarily constructed for thermo-electric measurements the D'Arsonval galvanometer must have included in circuit with the moving coil, to diminish the error due to changes in the temperature of the air, a large dead resistance of negligible temperature coefficient. This added resistance greatly reduces the sensitiveness of the instrument.

The device which I have adopted for overcoming this error effects a complete compensation without in the least diminishing the sensibility and thus permits the use of a pivoted coil which does not necessitate leveling the instrument. Incidentally the new design employs very light magnets so that the complete instrument weighs but three pounds.

The principle made use of in effecting the compensation is as follows: The deflection of a coil carrying a current in a field of magnetic force is proportional to the current traversing the coil and to the magnetic flux through the air gap of the magnet. The magnetic flux is, for a small air gap, inversely proportional to the length of the air gap, since the flux is proportional to the reciprocal of the reluctance and the latter is, owing to the low reluctance of steel, almost all in the air gap.

The method of applying the principle is illustrated in Fig. 3, which is a diagram of the electric and magnetic circuits of the gal-

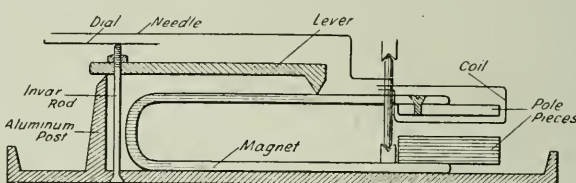


Fig. 3. Device for compensating for variation of resistance with temperature.

vanometer. The coil rotates about one of its ends in a uniform field between two plane pole pieces. The two magnets that are connected in parallel by these pole pieces differ from those ordinarily employed in being very thin and therefore quite flexible. These magnets are pressed together somewhat by the long end of a strong lever, the short end of which rests upon a post which is part of the aluminum case. Near the bearing of the lever on the post and at the proper distance from it the lever is pierced by a light rod of invar metal, which serves to apply pressure to the magnets. If the temperature of the air rises the aluminum post will expand much more than the invar rod, thus forcing the long end of the lever downward and diminishing the gap between the poles of the magnet by an amount which may be made accurately to compensate for the corresponding increase of electrical resistance in the coil. In practice the device is found to accomplish its purpose with remarkable accuracy, and thus to solve one of the

most serious difficulties in the way of making an accurate and at the same time sensitive portable galvanometer.

The portable galvanometer with receiving tube attached is shown in Fig. 4. An automatic arrestment for the coil is actuated by lifting the instrument by its handle. Fig. 5 shows a typical scale plate.

Fig. 4. Portable pyrometer complete.

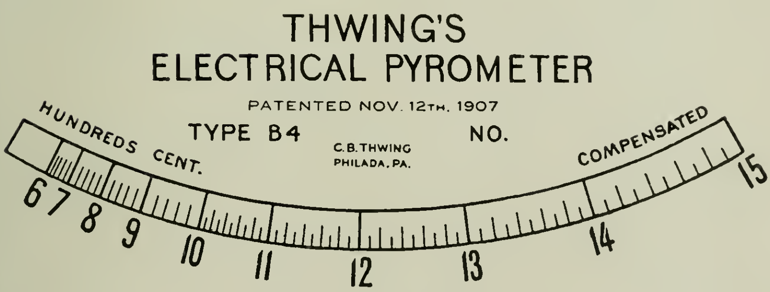


Fig. 5. A typical scale.

The pyrometer responds instantly to temperature changes, attaining a state of equilibrium in three or four seconds after pointing at the hot surface and returning as quickly to null reading when the radiations are cut off.

The possible range of temperature is unlimited in either direction. It has been adapted to the measurement of the temperature of mangle rolls in a laundry where the maximum temperature is 200° Centigrade. A contact couple was here objectionable because of its liability to collect and discharge dirt. Another example of the same sort is the measurement of boiler wall temperatures where contact of any sort of thermometer changes the magnitude of the quantity to be measured.

Fig. 6 shows a wall type galvanometer, and Fig. 7 a recorder. The record is made by pressing the period type, carried at the end of the pointer, upon the paper each alternate second. In the in-

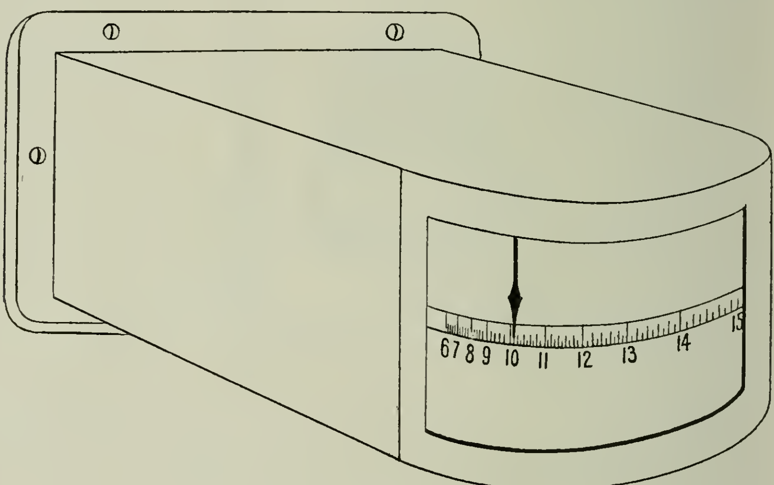


Fig. 6. Wall pattern galvanometer.

tervening seconds the needle returns to null position where it is pressed upon an ink pad. The entire record is visible at all times.

The Radiation Pyrometer is especially well adapted to the measurement of temperatures in open hearth furnaces and it was, of course, desired to supplement such measurements with determinations of the temperature of the molten metal at various stages. Numerous attempts made by the writer and others to measure the temperature of molten iron with the Féry radiation pyrometer led to results which were obviously much too low. The pyrometers employed were, in some cases, furnished for the express purpose of measuring temperature of molten iron, yet the reading obtained

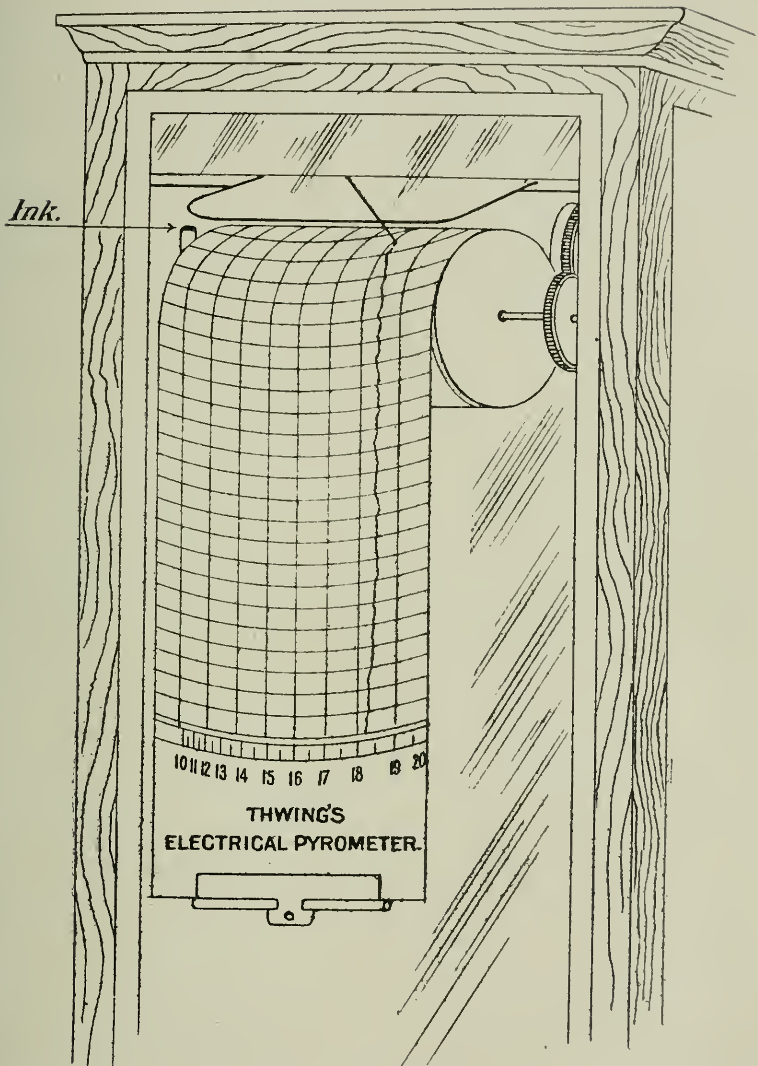


Fig. 7. Recorder.

by pointing the telescope at the flowing iron was considerably less than that obtained from the same iron when solidifying in the ladle.

A series of experiments tried with my pyrometer led to the conclusion that the emissivity of molten iron is much less than that of a black body and as no data were known a series of experiments were undertaken to determine, at least roughly, the value of the constant of radiation for molten iron and copper, since the importance of a knowledge of the temperature of these metals in various industrial operations is coming to be recognized as of considerable importance and the principle of total radiation furnishes a convenient method of making such measurements.

The results of these experiments were embodied in a paper read by the writer before the American Physical Society on October 19, 1907, and published in the Physical Review for February, 1908.

By direct comparison with a Le Chatelier pyrometer it was found that the intensity of the radiation from molten iron is but .28 as much and from molten copper but .14 as much as from a black body at the same temperature. It is necessary, therefore, to employ for such measurements an instrument calibrated for that purpose or else to multiply the readings obtained with a regular instrument by the proper constant.

SHRINKAGE OF WOOD WHEN DRIED.

Forest Service, Washington, D.C. Trade Bulletin No. 17.

Interesting experiments on the shrinkage of wood due to the loss of moisture have recently been completed by the Forest Service at its timber testing station, at Yale University. These experiments show that green wood does not shrink at all in drying until the amount of moisture in it has been reduced to about one-third of the dry weight of the wood. From this point on to the absolutely dry condition, the shrinkage in the area of cross-section of the wood is directly proportional to the amount of moisture removed.

The shrinkage of wood in a direction parallel to the grain is very small; so small in comparison with the shrinkage at right angles to the grain, that in computing the total shrinkage in volume, the longitudinal shrinkage may be neglected entirely.

The volumetric shrinkage varies with the different woods, being about 26 per cent. of the dry volume for the species of eucalyptus known as blue gum, and only about 7 per cent. for red cedar. For hickory, the shrinkage is about 20 per cent. of the dry volume, and for long-leaf pine about 15 per cent.

In the usual air dry condition, from 12 to 15 per cent. of moisture still remain in the wood, so that the shrinkage from the green condition to the air dry condition is only a trifle over half of that from the green to the absolutely dry state.—Forest Service, Forest Bulletin, No. 27.

Mining and Metallurgical Section.

(Stated meeting held Thursday, February 13, 1908.)

Practical Experiments in Steel.*

By Chas. L. Huston.

These experiments were undertaken in order to secure for practical purposes a more accurate knowledge of the interior character and structure of the material we are constantly dealing with in the manufacture of what is technically known as boiler plate steel, and used in the construction of boilers, bridges, ships, etc., where the safety of the travelling public is of vital consideration; where I think no one will dispute the statement that we ought to know all that we can learn about the characteristics of the material which enters into this and the safety of the ultimate structure made from it.

Much progress has been made since the first attempt to examine into and specify the character of material to be used in steam boilers, bridges, etc., but through it all I think the records will show the constant effort on the one hand to secure a material of higher tensile strength for carrying higher pressure or heavier loads with, on the other hand, continual vigilance on the part of those upon whom the responsibility of the public safety rests, to require evidences of ductility in the material to avoid the danger point which is approached when the increased tensile strength called for reaches the stage where brittleness results.

My late lamented father, Dr. Charles Huston, took a great interest in the earlier history of these questions and trained up his sons who succeeded him in the manufacture of boiler plate, with a

*For the use of the illustrations accompanying this paper the *Journal* is indebted to the *Proceedings of the American Society for Testing Materials.*

strong sense of their responsibility for the elements of safety in the material manufactured and put upon the market.

In the old days of iron, a sample selected from one part of the plate made in the usual manner was as a rule fairly representative of the quality of the material through the remainder of the same plate, the principal element of uncertainty being the question of incomplete welding.

In the early days of the use of steel it was assumed and generally believed that because the metal was all melted together and poured into large ingots to be rolled or otherwise worked into shape, the plates or shapes resulting would be almost, or absolutely, solid and homogeneous in character, but experience has shown that this early conception has not been entirely borne out, and men have found that the material is not absolutely solid, nor entirely uniform in character throughout the mass.

This lack of uniformity has become more noticeable as larger masses have been used, so that a careful investigation into the distribution and degree of this inequality seemed important.

It has been thought by many that the hardening elements were gathered toward the top of the ingot mass by floatation, and that if a good portion of discard was cut from this top end the remainder of the material would be comparatively uniform.

Others have discovered a tendency in hard or medium steels to segregate the hardening elements toward the center or axis of the mass and have concluded, as I also did at first, that this applied to soft steels as well, and that the resultant of this in combination with the floatation tendency was to form a trumpet-shaped hard portion somewhat similar in shape to the inverted "Christmas Tree" observed in a block of manufactured "can" ice.

With this in mind and a desire to examine into the general soundness and structure of some of our standard boiler steel ingots, I had several of them bi-sected vertically, and photographed, with drillings taken from the cut face, and analyses made from representative locations and properly grouped in a chart.

Several of these half ingots resulting from this bi-secting process I had rolled down into plates; also duplicates of the other bi-sected ingots rolled down into plates and cut up to get samples for physical testing purposes with the results appropriately charted, together with further analyses from the corresponding tests; I also show several additional charts to indicate the character and

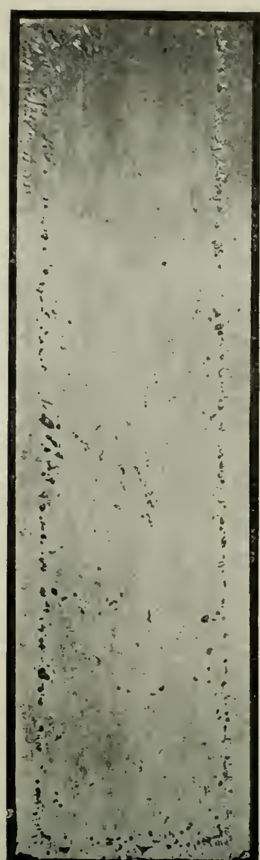


Photo. 1

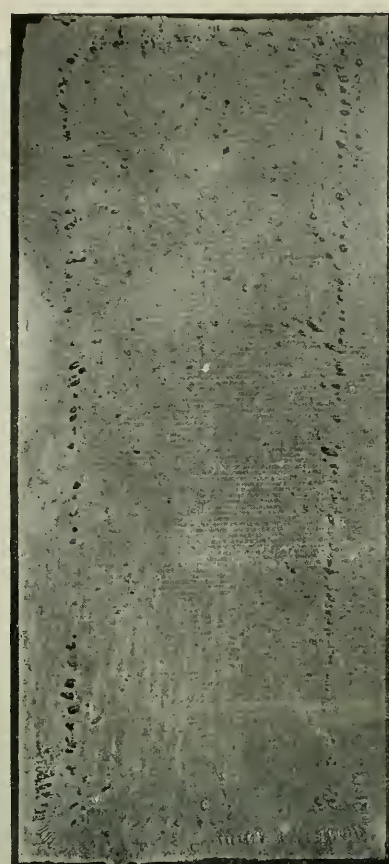


Photo. 2

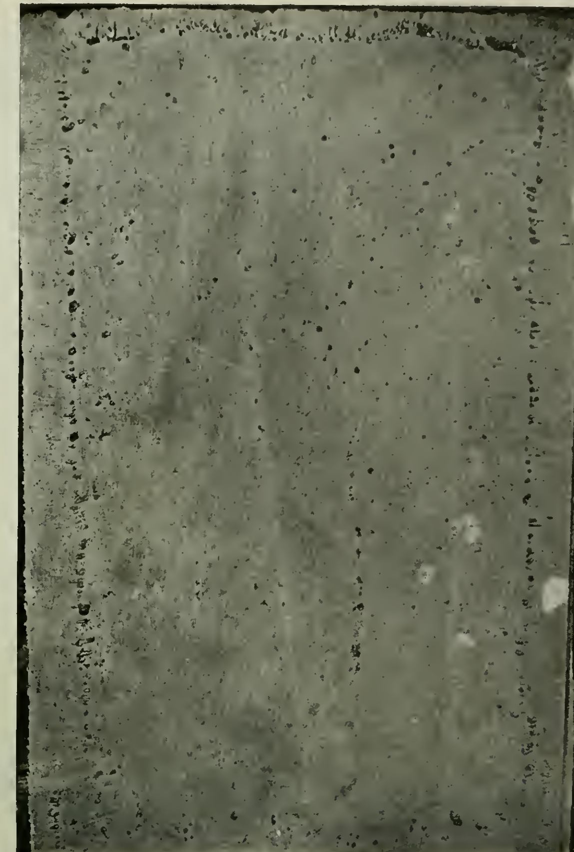


Photo. 3

degree of segregation in ingots of widely differing weights and shapes.

This much for general description and introduction.

Returning to the description of the charts and taking them up by number they may be described as follows:

Photo. 4

Ingots as shown in photos Nos. 1, 2, 3, and 4 were all "bottom" poured at the same time in one group so as to see what, if any difference resulted from difference in shape and weight of ingot mass.

No. 1, 9″ x 12″ section; No. 2, 16″ x 18″; No. 3, 12″ x 26″,

and No. 4, 8″ x 38″, all about 36″ high, and showing carbon by ladle test .18.

Test charts Nos. 2, 3 and 4 were made from tests of plates rolled from exact duplicates of ingots No. 2, 3, and 4, poured in the same group.

These plates were all rolled about 31 feet long, 76″ wide and 5/16″ thick. Ingot No. 1 weighed about 900 pounds, while Nos. 2, 3, and 4 weighed about 2850 pounds each, the cross section, while varying decidedly in proportion, figuring up about the same area, and hence resulting in the same weight ingot.

Photo No. 5 was from the sample earlier described (size of ingot, 22″ x 15″, weight, 3775 pounds) as first bisected; section photographed and then the half ingot rolled into a plate for physical and chemical test as shown in test chart No. 5 (ladle test carbon .23, plate ⅜″ thick.)

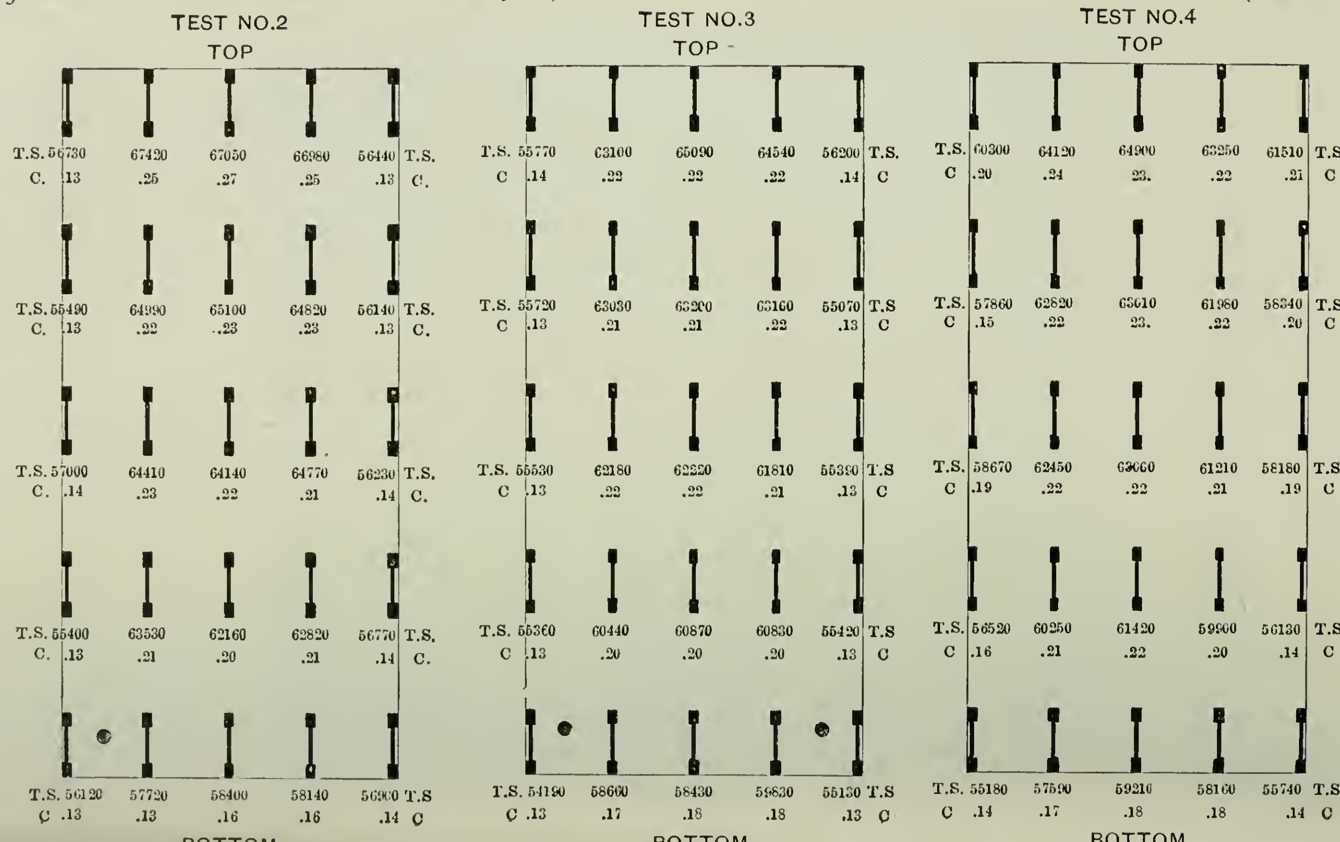
Test chart No. 6, is from a larger size of ingot (not cut for photograph) and rather higher carbon, being of quality and carbon suitable for what is known as "Marine Steel," used for steamboat boilers, and subject to specifications of United States Board of Supervising Inspectors of Steam Vessels; this ingot was 20″ thick by 48″ wide, and weighed about 11,000 pounds; the plate was rolled to 29/32″ thick.

Test chart No. 7, (ingot not cut for photograph) was rolled from a large ingot 30″ thick by 34″ wide, weighing about 18,000 pounds, first rolled down and cut into eight slabs 29″ wide by 3½″ thick, then slabs reheated and rolled into plates ⅜″ thick all of one size for physical and chemical test, the location of the slabs as they were cut being carefully noted and traced so as to properly group the tests of the plates in the chart. Ladle test carbon 0.19.

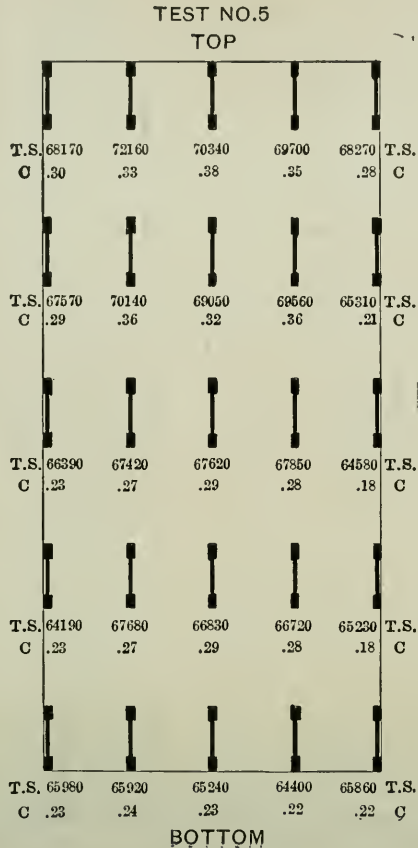
No. 8, photograph shows an ingot cut in a rather different manner, having a quarter section cut out in order to observe the structure of the material in both ways of the section, after photographing.

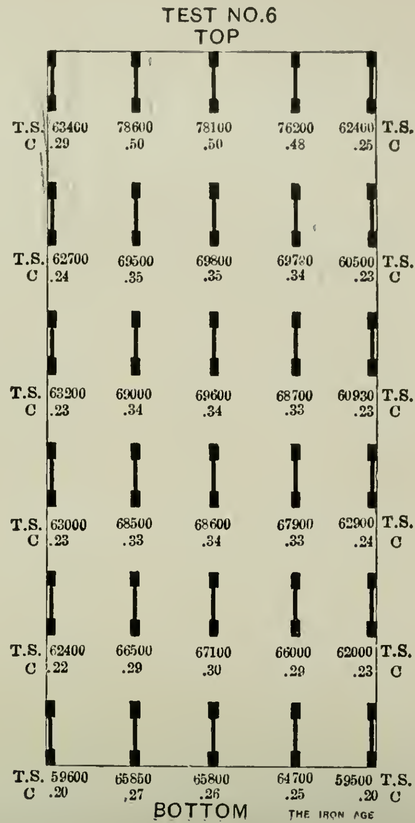
The other quarter section was cut away and samples taken for chemical analysis, and the remaining bi-sected ingot rolled into a plate for physical test, as shown in test chart No. 8.

Test Chart No. 9, shows carbon determinations from drillings in the ends of the large slabs cut from an ingot of 30″ x 50″ size, weighing 30,600 pounds, the slabs being 50″ wide by 15″ thick. Ladle test carbon 0.23, the drillings being taken from the ends of

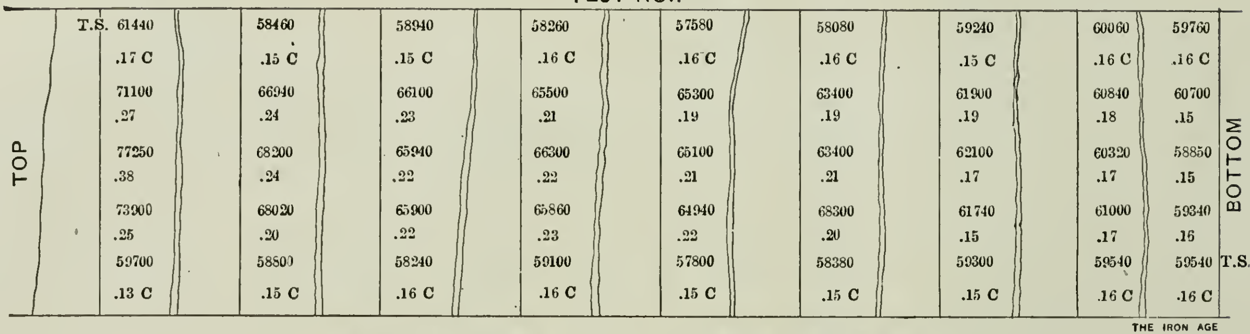

TEST NO.2
TOP
T.S. 56730 67420 67050 66980 56440 T.S.
C. .13 .25 .27 .25 .13 C.
T.S. 55490 64990 65100 64820 56140 T.S.
C. .13 .22 .23 .23 .13 C.
T.S. 57000 64410 64140 64770 56230 T.S.
C. .14 .23 .22 .21 .14 C.
T.S. 55400 63530 62160 62820 56770 T.S.
C. .13 .21 .20 .21 .14 C.
T.S. 56120 57720 58400 58140 56900 T.S
C .13 .13 .16 .16 .14 C
BOTTOM
TEST NO.3
TOP
T.S. 55770 63100 65090 64540 56200 T.S.
C .14 .22 .22 .22 .14 C
T.S. 55720 63030 63200 63160 55070 T.S
C .13 .21 .21 .22 .13 C
T.S. 55530 62180 62220 61810 55390 T.S
C .13 .22 .22 .21 .13 C
T.S. 55360 60440 60870 60830 55420 T.S
C .13 .20 .20 .20 .13 C
T.S. 54190 58660 58430 59630 55130 T.S
C .13 .17 .18 .18 .13 C
BOTTOM
TEST NO.4
TOP
T.S. 60300 64120 64900 63250 61510 T.S.
C .20 .24 23. .22 .21 C
T.S. 57860 62820 63610 61960 58340 T.S.
C .15 .22 23. .22 .20 C
T.S. 58670 62450 63660 61210 58180 T.S.
C .19 .22 .22 .21 .19 C
T.S. 56520 60250 61420 59900 56130 T.S
C .16 .21 .22 .20 .14 C
T.S. 55180 57590 59210 58160 55740 T.S.
C .14 .17 .18 .18 .14 C
BOTTOM

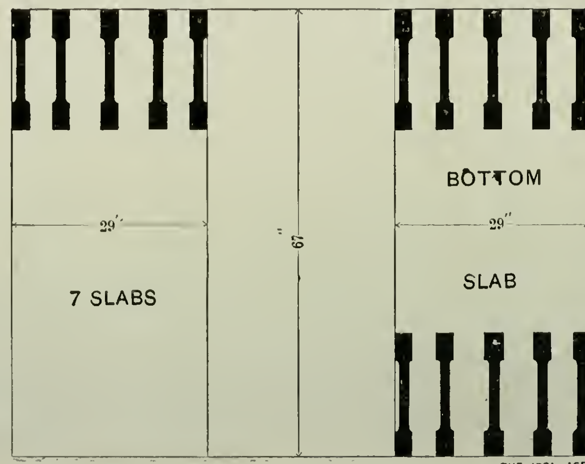
Photo, 5


TEST NO.5
TOP
T.S. 68170 72160 70340 69700 68270 T.S.
C .30 .33 .38 .35 .28 C
T.S. 67570 70140 69050 69560 65310 T.S.
C .29 .36 .32 .36 .21 C
T.S. 66390 67420 67620 67850 64580 T.S.
C .23 .27 .29 .28 .18 C
T.S. 64190 67680 66830 66720 65230 T.S.
C .23 .27 .29 .28 .18 C
T.S. 65980 65920 65240 64400 65860 T.S.
C .23 .24 .23 .22 .22 C
BOTTOM


TEST NO.6
TOP
T.S. 63400 78600 78100 76200 62400 T.S.
C .29 .50 .50 .48 .25 C
T.S. 62700 69500 69800 69720 60500 T.S.
C .24 .35 .35 .34 .23 C
T.S. 63200 69000 69600 68700 60930 T.S.
C .23 .34 .34 .33 .23 C
T.S. 63000 68500 68600 67900 62900 T.S.
C .23 .33 .34 .33 .24 C
T.S. 62400 66500 67100 66000 62000 T.S.
C .22 .29 .30 .29 .23 C
T.S. 59600 65850 65800 64700 59500 T.S.
C .20 .27 .26 .25 .20 C
BOTTOM
THE IRON AGE

TEST NO.7


TOP
T.S. 61440
.17 C
71100
.27
77250
.38
73900
.25
59700
.13 C
58460
.15 C
66940
.24
68200
.24
68020
.20
58800
.15 C
58940
.15 C
66100
.23
65940
.22
65900
.22
58240
.16 C
58260
.16 C
65500
.21
66300
.22
65860
.23
59100
.16 C
57580
.16 C
65300
.19
65100
.21
64940
.22
57800
.15 C
58080
.16 C
63400
.19
63400
.21
68300
.20
58380
.15 C
59240
.15 C
61900
.19
62100
.17
61740
.15
59300
.15 C
60060
.16 C
60840
.18
60320
.17
61000
.17
59540
.16 C
59760
.16 C
60700
.15
58850
.15
59340
.16
59540 T.S.
.16 C
BOTTOM
THE IRON AGE


29"
7 SLABS
67"
BOTTOM
29"
SLAB
THE IRON AGE

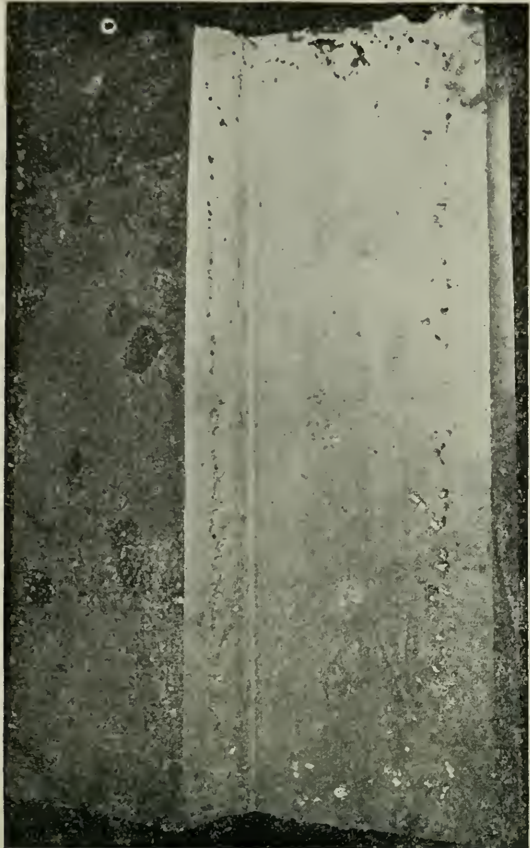
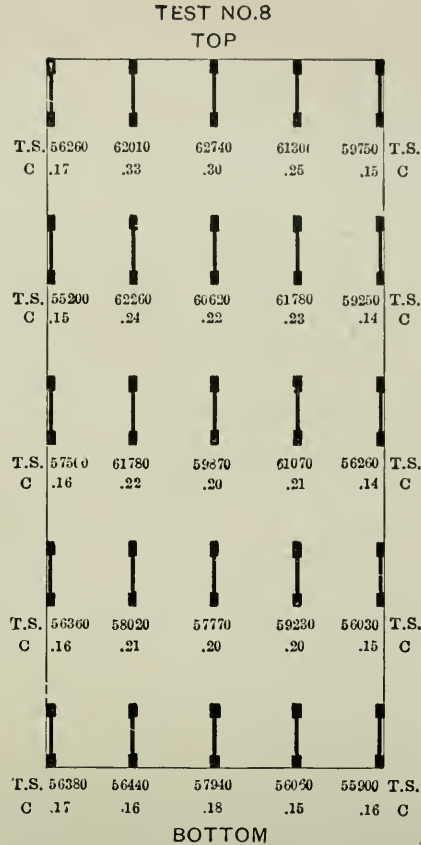
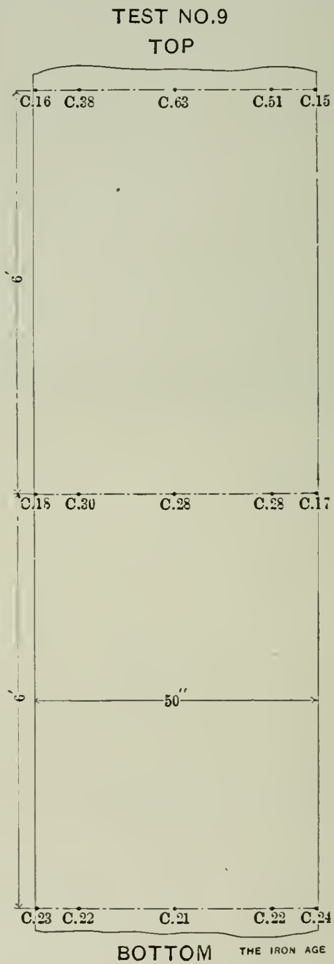


Photo. 8


TEST NO.8
TOP
T.S. 56260 62010 62740 61300 59750 T.S.
C .17 .33 .30 .25 .15 C
T.S. 55200 62260 60620 61780 59250 T.S.
C .15 .24 .22 .23 .14 C
T.S. 57500 61780 59870 61070 56260 T.S.
C .16 .22 .20 .21 .14 C
T.S. 56360 58020 57770 59230 56030 T.S.
C .16 .21 .20 .20 .15 C
T.S. 56380 56440 57940 56060 55900 T.S.
C .17 .16 .18 .15 .16 C
BOTTOM

the slabs as cut, so as to represent the central plane of the ingot metal.

These last two charts, Nos. 8 and 9, consequently show the carbon determinations for the central plane of the ingot, while all



the preceding ones show the carbon results from drillings taken entirely through the rolled plate, and hence correspond with the whole thickness of metal which each physical test piece represents, the drillings in each case being located to correspond as nearly as possible with the location of its corresponding sample for physical test.

When the physical and chemical test represent the same metal it will be noted that there is a close correspondence between the results, but when the carbon test represents only the central plane of the ingot as in charts Nos. 8, 9, and 10, the variation in carbon is greater proportionately than the variation in physical properties.

Chart No. 10 is a record of carbons taken across the face of the ingot shown in plate No. 3 and represented by chart No. 3, and made to ascertain where the greatest segregation lay in the line across the transverse axis of the ingot.

It will be seen from these charts showing a wide range of sizes and shapes of ingots that the general character of the segregation is the same.

As the steel cools in the mold a steadily thickening wall of solidified metal forms against the sides of the mold (which is usually of cast-iron) and numbers of gas bubbles form and rise to the surface in the liquid portion, causing a rising current of metal adjacent to the solidified wall with return downward current in the center.

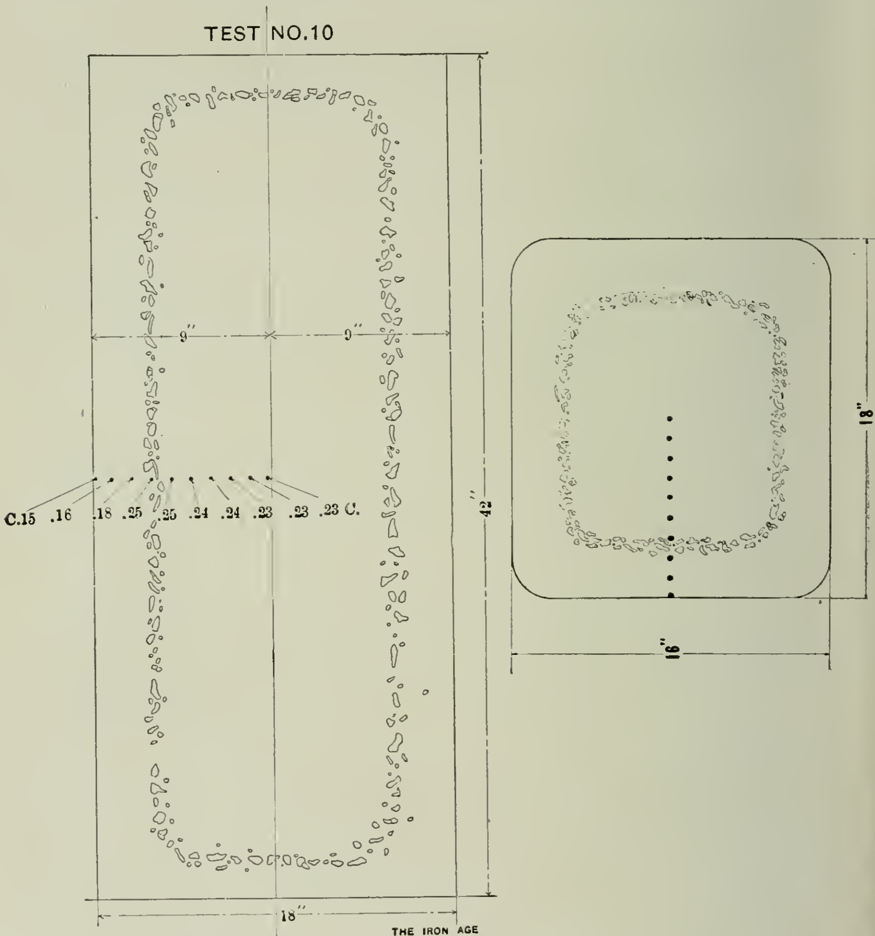
This causes thorough mixing of the portion remaining liquid, but as the carbon and other elements are expelled from the solidifying wall the central liquid portion continually gains in these elements.

This action continues until the temperature of the liquid portion falls to a point where its consistency becomes so thick that the gas bubbles cannot rise through it, when circulation ceases, gas formation ceases and segregation ceases and the metal inside this zone of gas bubbles solidifies in a mass of comparatively uniform character.

The depth from the outside at which these gas bubbles are held may be varied somewhat by the condition and temperature of the metal when poured, but so far as the author of this article knows they have never been entirely eliminated from standard carbon steels.

They may form in a double line with the first one immediately in contact with the mold, resulting in a bad surface in the product, or they may congregate near the center and form large pockets or a pipe, but like the poor, they are "always with us," in some shape, and the disposition of them as indicated in these charts seems to be the best we can make of them so far.

Chart No. 10, shows what might be expected, viz., that the greatest degree of segregation in the transverse axis of the ingot is adjacent to the zone of gas bubbles, the carbon which was last expelled from the solidified metal being held in the adjoining por-



tion of the central mass of metal which was at the time of too thick consistency to circulate and distribute it, the central vertical axis having less carbon than this gas bubble zone except near the top, as indicated by the charts of tensile strength.

It will be manifest from these experiments that the specimens of plate steel available for testing purposes, which as a rule have

to be taken from shearings from the outer margin of the plates as rolled, show the softest part of the metal, and hence there is in the interior much harder metal, in the case at least of very heavy plates, whether rolled directly from the ingot or from the slab, and in any event there is much larger variation in the character of the metal in a large plate than is usually supposed.

This being the case, coupled with the fact that conditions usually require all or part of the test pieces to be cut from the outside softer portions of the plate, brings about a very risky state of things when, in order to carry high pressure, high tensile strength is specified, because it results in the use of material often so hard in its interior portions as to suffer distress in working to shape and reduces the actual factor of safety in the finished structure.

In the earlier rules adopted by the Philadelphia Department of Public Safety in 1882 for iron plates a factor of safety of five was provided for metal of moderate ductility, but where the ductility was high a factor of safety of four was granted, thus encouraging the use of soft, tough metal.

It would be well if some plan could be adopted now and put into general use which would automatically encourage the use of soft ductile metal, thus securing increased safety to the travelling public and doing away with a lot of difficulty and contention between makers and the inspectors who represent the users of the metal; whose rejection of quantities of material often occurs simply because it falls slightly below the required minimum limit, though this material because of its greater ductility can withstand being worked into the required form for the finished boiler with less risk of weakness developing and is more worthy of carrying the required unit stresses under conditions of service than would be a harder metal of the same thickness.

Under present general engineering practice the working stresses allowable are based entirely upon the minimum tensile strength shown, ductility and maximum tensile being introduced only as a check.

It would be far better I believe if the ductility were introduced as a factor in conjunction with tensile strength to determine the allowable working stresses so that a somewhat lower tensile steel may be used, where it shows a corresponding increase in ductility.

In fact I believe it would result in great improvement over

present practice first to determine the maximum unit stress and then specify the range of tensile stress allowable in the steel coupled with a corresponding proper ductility showing; for instance, given a maximum unit stress of 12,000 pounds per square inch for one class of service specify that the steel shall be allowed a range from 50,000 to 60,000 pounds T. S., provided it also shows a ductility of 1,500,000 pounds divided by the actual T. S. in pounds.

This would result in a factor of safety of five with steel of ordinary ductility, but where the ductility showing is high permit a somewhat less factor of safety, and thus encourage the use of soft steels which, judging from experiences of many years, would result in far greater safety to the public service.

The above suggestions are applicable only to material to be used in tension.

For material to be subjected to compression or to bending (which is a combination of tension and compression) or to alternating stresses or to vibration, different rules would have to be worked out, each adapting to the conditions of service; first, study all that can be learned of the material and conditions of service, and then use "horse sense" in adaptation of material and the adoption of rules to secure the needed qualities in material without imposing unnecessarily difficult or impractical conditions upon manufacturers of the materials, and in the rules establish sufficient elasticity to allow the exercise of reasonable discretion on the part of an intelligent and practical inspector.

We should then all get along better together and secure, I believe, better material without the rejection and waste of a lot of good material, as often occurs under present rules and methods.

Section of Physics and Chemistry.

(Stated meeting held Thursday, February 6, 1908.)

The Electron Theory.

By Edward A. Partridge.

The object of this paper is to set forth the electron theory and to describe briefly its experimental foundations. The theory came into being when it was established that negative electricity is atomic in character; that a negative charge is always a whole number multiple of a definite indivisible quantity of negative electricity. The atom of negative electricity has been named an electron. The first hint that electricity is discontinuous was given by Faraday's work on electrolysis.

To show that in electrolysis equal quantities of electricity are always associated with equal numbers of atoms of a monovalent element and that the ratio between the quantity of electricity passed through a solution and the number of atoms set free is twice as great for a divalent element as for a monovalent element, is to indicate that matter and electricity are similar in constitution.

But Faraday's laws of electrolysis remained for more than fifty years the only statement of fact best explained on the hypothesis of atomic electricity.

Maxwell's far-reaching theory of electricity and its immediate consequence, the electromagnetic theory of light, seemed to fasten attention upon differential equations and to cause men to be satisfied with a mathematical statement of the propagation of a disturbance and not to inquire concerning the nature of electricity. Then, too, the experimental verification by Hertz of Maxwell's theory emphasized its importance. But how unsatisfactory the

theory of electricity seemed to students fifteen years ago. There was little connection between electrostatics and electrolysis, or between electrodynamics and the theory of thermocurrents, and the phenomena of vacuum tubes were but little understood.

It is in this last field that the greatest harvest of truth has been reaped. Sir William Crookes, in 1879, read a paper entitled "Radiant Matter." In that paper he described many of the phenomena caused by what we now call kathode rays. He maintained that the effects he described were due to streams of negatively electrified particles of matter that were shot off from the kathode and by their mechanical energy produced the observed effects. Crookes' view was opposed by the Continental physicists and defended by the English, with the result that the phenomena have been most thoroughly investigated in a long series of brilliant experiments. One of the side results of the work with vacuum tubes was the discovery of Röntgen rays. Finally it has been established that the properties of the kathode rays are independent of the nature of the residual gas in the tube. A kathode ray particle possesses the same mass and the same charge of negative electricity if produced in hydrogen or oxygen, carbon dioxide or helium.

The determination of the velocity and $\frac{e}{m}$; that is, the ratio of charge to mass has been accomplished by extremely ingenious experiments. One method of measuring the velocity and $\frac{e}{m}$ is to determine in the same kathode ray tube, the charge carried in a given time by the kathode rays, the heat developed by their impact, and the deflection of the stream by a magnetic field of known strength. The first of these quantities depends upon the number of particles and the charge on each. The second on the number and the mass and velocity of each. The third on the ratio of charge to mass and the velocity of each. From the equations expressing the actual relations the number of particles can be eliminated and the velocity and $\frac{e}{m}$ found. The velocity under ordinary conditions turns out to be of the order of one-tenth the velocity of light. The ratio $\frac{e}{m}$ is about one thousand times the corresponding ratio for the hydrogen atom in electrolysis. J. J. Thomson, to whom much of this work is due, named the kathode ray particle, a corpuscle. In the interpretation of this ratio we are confronted by two possibilities, either the corpuscle is an atom of hydrogen with a charge one thousand times greater than the charge carried by

the same atom in electrolysis or we are dealing with masses smaller than the hydrogen atom.

The study of radiation, and in particular of the spectra of the elements has for many years rendered familiar the notion that an atom is not an absolute unit, but is a complex, whose parts are capable of vibration within the atom. Iron, for instance, yields a spectrum consisting of hundreds of lines, every one of which corresponds to a vibration within the system that we call an atom. The electromagnetic theory of light teaches us that it is electricity that vibrates in an atom. To account for the series of doublets and triplets in many spectra, Stoney considered the atom as something like a diminutive solar system with the places of the sun and planets taken by minute electric charges. He called these charges electrons. From a consideration of the mutual perturbations of their orbital motions he formed a rational explanation of the existence of the doublets and triplets in spectra.

If the light emitted by a body is due to electrical oscillations within the atom, a magnetic field will modify the period of oscillation. Zeeman, in 1897, discovered this effect. A spectral line is split into two if the light-giving source is placed in a powerful magnetic field and observed along the lines of force; into three, if observed at right angles to the magnetic field. The amount of the separation produced by a field of known strength permits the ratio of charge to mass of the vibrating electron to be calculated. It turns out to be the same as $\frac{e}{m}$ for the kathode rays. When a single spectral line is split into two by looking along the lines of force each component of the magnetically produced doublet is circularly polarized, the circular polarization being in opposite directions. The triplet observed on looking at right angles to the lines of force is characterized by the two lateral components showing plane polarization in planes at right angles to each other, while the central component is unaffected. These polarization effects demonstrate that the lines in a spectrum are produced by vibration of negative electricity.

This is the description of the Zeeman effect in the simplest form as it had been foreseen by Larmor and Lorentz long before it was observed. In addition to this simple phenomenon many lines show a much more complicated behavior, resolving into numerous components when the source is in a powerful field. The vibration frequencies corresponding to lines in spectra have been

shown to be related by a comparatively simple law and have been arranged in series. The Zeeman phenomenon is the same for all the lines belonging to the same series and for the corresponding series in related elements. In a recent paper Jean Bacquerel has shown that the absorption bands in the spectra is xenotim and tysonite are affected in a manner strictly analogous to the splitting up of the lines in emission spectra. Xenotim, a phosphorous compound of yttrium and erbium, and tysonite a flourine compound of cerium, lanthanum and didymium were selected for examination because they possess particularly narrow absorption bands. At the temperature of liquid air the bands become much sharper.

The ratio $\frac{e}{m}$ having been determined by several methods, suggests the measurement of the quantities e and m separately. Here we encounter some most interesting work.

Röentgen rays, radium rays and ultra-violet light ionize air or other gases through which they pass. That is to say, they render the air conducting by forming ions. By measuring the maximum current that a given volume of the gas can carry, the quantity of electricity existing on the charged ions is found. If air saturated with water vapor is suddenly expanded it will be cooled and become supersaturated in the absence of condensation nuclei. Dust particles or gaseous ions serve equally well for condensation nuclei. If saturated air freed from dust by filtration is ionized and expanded the right amount, condensation in minute drops will take place about the negative ions only.

The size of a drop can be calculated from its rate of fall, the total amount of water condensed from the cooling by expansion. So the number of drops, hence the number of condensation nuclei follows as the quotient of the total volume of water condensed divided by the volume of a drop. Knowing the number of nuclei and the amount of electricity existing as charge on ions we have the charge on one ion. The result of the calculation is that the charge on a gaseous ion is the same as on a hydrogen atom in electrolysis. This charge is the same no matter what the gas or the ionizing agency. The final conclusion is that the "m" in the ratio $\frac{e}{m}$ is 1/1000 of the mass of the hydrogen atom.

Hertz found that ultra violet light enabled an electric spark to jump, under conditions that otherwise would permit no spark to pass. Long study has shown that a negatively electrified metal sphere will lose the charge when illuminated by ultra-violet light.

A positive charge is not affected. Investigation of this phenomenon has developed the fact that the illuminated body emits electrons and that these electrons ionize the air in the vicinity thereby rendering it conducting. Lenard studied the magnetic deflection of a stream of photo-electrons and measured the ratio $\frac{e}{m}$. Again we find the same value. J. J. Thomson by another method also obtained practically the same result.

In a recent paper Erich Ladenburg has described experiments that demonstrate that the velocity of the projected photo-electrons depends upon the wave length of the ultra-violet light that cause the phenomenon. The velocity increases with the increase of the frequency of the light vibration. This fact adds weight to the hypothesis that the electrons are torn from atoms by electric oscillations that have periods approximately equal to the natural periods of the electrons themselves. The conclusion is plain when we remember that the greater the force retaining an electron in place the shorter would be its natural period, that is, the greater its speed of oscillation and the greater velocity would it have when separated from the atom. In other words, we are dealing with a resonance phenomenon. This view is corroborated in a remarkable manner by a consideration of the optical properties of bodies as worked out by Drude in one of his last works.

Drude was ever on the alert to seize upon any method that promised to yield a clue to the constitution of matter or to reveal a connection between chemical constitution and physical properties. In 1904, Schuster published a paper in which he gave a value for the number of free electrons in metals. Drude immediately took up the idea and greatly developed it, although his results do not agree with Schuster's. The attack proceeds from the theory of dispersion based upon the electromagnetic theory of light as worked out by Helmholtz, Drude, Planck, and Lorentz. For many transparent substances the index of refraction for a wave of given frequency is shown to depend upon the frequencies of the natural vibration proper to the substances. These natural frequencies in the cases of substances having so-called normal dispersion lie far in the ultra-violet or infra-red. The formulæ yield the values $\frac{e}{m}$ for the vibrating matter and also the number of comparatively loosely bound electrons in the molecule.

The value of $\frac{e}{m}$ for the particles having the ultra-violet natural frequency is the same as the same ratio for the kathode rays. The

value for the mass vibrating naturally at the infra-red rate shows that this mass is either a molecule or part of a molecule. In the cases of bodies that show anomalous dispersion the absorption bands are caused by the natural vibration of electrons, not of molecular masses. The importance and certainty of the method is shown by the fact that $\frac{e}{m}$ calculated from the dispersion of hydrogen is 1.5×10^7, while the rate for kathode rays, as determined by Kaufmann, Simon, and Seitz, is 1.86×18^7.

The values of the number of freely movable electrons in a metal as calculated from the optical properties vary from .5 to 7.5 per atom of metal. These numbers agree in general with values to be expected from a consideration of the thermo-electric electromotive forces. The number of conduction electrons, as Drude calls them, in bismuth is particularly small, in antimony particularly great, agreeing with the well-known large thermo-electric electromotive force of a bismuth-antimony couple. Hagen and Rubens have measured the emissivities of a number of metals for very long wave lengths. These numbers permit a calculation of the number of free electrons per cubic centimeter; the results obtained agree well with those derived from a consideration of the optical properties of the metal.

Siertsema has calculated the ratio $\frac{e}{m}$ from the dispersion of the magnetic rotation of the plane of polarized light and obtained a value agreeing well with that reached by other methods.

The electron theory has been applied to explain the electrical properties of metals. This application has been made principally by Drude and Riecke. In solid metals some of the electrons are free and move in the intermolecular spaces according to the laws that govern the motion of the molecules of gases in an enclosed space, and move with an average velocity corresponding to their mass and temperature, *i. e.*, they participate in the motion that is the heat in the body. According to the theory as developed by Drude in its simplest form, the conduction of heat takes place by means of electrons, the molecules being constrained to vibrate about a mean position of equilibrium without collision, while the electrons have the progressive motion ascribed to molecules in the kinetic theory of gases. Electric conduction takes place in consequence of the forward motion between collisions, the forward motion being produced by a constantly acting electric force or difference of potential. The ratio between the conductivities for

heat and electricity turns out to be a constant for all metals and proportional to the absolute temperature. But there are exceptions to this law of Wiedemann and Franz. These exceptions together with the Volta contact differences of potential and thermo-electric electromotive forces compel us to assume that the number of free electrons is dependent upon temperature, and further that the positively charged atomic residues take some part in the conduction of heat and electricity. The greater the deviation from the law of Wiedemann and Franz the greater is the part played by the positively charged atomic residues.

Since the electrons are considered as behaving like the molecules of a gas there will be a definite electronic pressure at a given temperature. Consider a piece of metal whose ends are at different temperatures. The electronic pressure must be the same throughout, therefore the density of the electrons must be less at the place of higher temperature, and we will have a difference of potential between the ends of the piece of metal. The work done by or against the electromotive force and the consequent development of absorption of heat make up the Thomson effect. Contact difference of potential is due to the establishment of equilibrium between different metals that have different numbers of electrons per cubic centimeter.

The electromotive force of a thermo-couple is made up of the electromotive force mentioned in the description of the cause of the Thomson effect and also of the contact electromotive forces of the two metals at the different temperatures. An analysis of the question shows that if the number of electrons in the two metals is independent of the temperature, the thermoelectric electromotive force is proportional to the difference in the temperature between the junctions.

The electron theory of metallic conduction yields a most satisfactory explanation of the Hall effect and the associated phenomena discovered by Nernst, Ettingshausen and Laduc. The Hall effect, discovered at Johns Hopkin in 1878, is the lateral deviation of an electric current that is flowing through a magnetic field. The effect is observed by passing a current through a thin rectangular plate of metal that is between the poles of a powerful magnet. If connection be made to the sides of the plate and the magnet excited, a lateral current is observed. If an electric current were maintained by equal progression of positive and nega-

tive units in opposite directions there would be no Hall effect. For opposite charges moving in opposite directions would be deflected to the same side of the plate. The existence of the Hall effect demonstrates that an electric current consists of a flow that is greater in one direction than the other. The direction of the Hall effect shows that it is the negative electrons that are principally concerned in the phenomena of electric currents. In addition to the Hall effect there are a number of concomitant effects that have been discovered later, there is a difference of temperature developed between the edges and also a longitudinal difference of temperature and difference of potential. There are four entirely analogous phenomena to be observed if a current of heat is passed through the plate that is in a magnetic field. Zahn, in 1904, made an elaborate study of this field and examined his experimental results in the light of Drude's theory. His conclusion was that the theory was well substantiated if the minuteness of the quantities and the experimental difficulties were taken into consideration.

The ratio $\frac{e}{m}$ for an electron has been determined by several distinct methods with practically identical results. Because of the invariability of the properties of kathode rays when the residual gas in a vacuum tube is changed the question arose, "Is the 'm' involved in this ratio, matter in the ordinary sense?" A negative answer to this question has been rendered possible by the following course of reasoning: A charge of electricity possesses inertia. To be explicit: a sphere of metal charged with electricity requires a greater force to produce a given acceleration in it when the sphere is charged than when it is not. This fact was established in a mathematical paper by J. J. Thomson in 1881. A moving charge is an electric current. An electric current is associated with a magnetic field, which possesses a definite amount of energy. A change in the velocity of the charge means a change in the intensity of the magnetic field, that is, a change in the amount of energy stored in the field. To add energy to the field requires work to be done; a force to act through a distance.

We have long been familiar with the idea of self-induction and have illustrated the idea by saying that an electric current acts as if it possessed inertia. In future we shall say, "an electric current possesses inertia." Indeed the idea is fast gaining ground that what was called the quasi-inertia of an electric charge is the

only inertia with which we have to deal. The inertia of a charge at rest is $\frac{2 U E^2}{3 A}$, according to the calculation of Thomson.

In this formula U is the magnetic permeability of the medium, E is the charge, and A is the radius of the sphere. Since the radius appears in the denominator, the less the radius, the greater the inertia. Consequently, any charge however small may have any inertia however great if we make the radius sufficiently small.

In this connection an additional truth developed by Heaviside and J. J. Thomson is of paramount importance. These men have shown mathematically that the inertia of a charge is not a constant quantity but a variable, that increases with the velocity of the charge. The truth of this statement can be seen almost intuitively, if we remember that an electromagnetic disturbance is propagated with the velocity of light and that therefore the lines of force of a moving charge are not radial as they are when the charge is at rest, but are bent backward approaching the equatorial plane. As a line of force in Maxwell's theory is a line of electric displacement and a varying displacement is an electric current the motion of a line of force in the direction of its length will not produce a magnetic field as there is no current there being no varying displacement. The greater the angle up to 90° between the direction of the lines of force and the direction of motion the greater the magnetic field that is produced. Therefore a variation of velocity when the lines of force are bent backward so as to approach the equator of the moving spherical charge will cause a greater expenditure of energy; the exertion of a greater force, which is the same as overcoming a greater inertia.

The formula expressing the dependence of inertia upon velocity shows that the change in inertia is slight until velocities approaching that of light are reached. In the neighborhood of the velocity of light the increase in inertia is very rapid so that inertia asymptotically approaches infinity with increasing velocity, reaching infinity at the actual light velocity. This deduction from theory has been subjected to experimental test by several experimenters. The first work in this line was with kathode rays, but the velocities are not sufficient to cause changes of inertia much beyond the limits of experimental error. Stark has, however, demonstrated a slight increase of inertia in extremely rapid kathode rays.

The crowning work in this field has been done by Kaufmann, of Göttingen, who has determined the ratio $\frac{e}{m}$ for the β rays of radium by simultaneously observing the deflection produced by electric and magnetic fields of known strength. Rays from a small quantity of radium salt were permitted to pass through a small hole in a piece of lead and then to pass through the electric and magnetic fields maintained in the same space, and finally to fall upon a photographic plate. The difficulty of the experiment can be appreciated by noting that the exposures were of two or three days' duration, and that the electric and magnetic fields had of course to be maintained constant during the entire time. Owing to the fact that β rays from radium are not homogeneous but have very different velocities, the electric and magnetic fields spread them out into a kind of spectrum, each point of which corresponds to a particular velocity. The measurement of the deviations permits the determination of both "m" and the velocity. Kaufmann has demonstrated not only that the mass increases with increasing velocity, but also that the entire mass is due to the charge of electricity that constitutes the particle. From Kaufmann's measurements a judgment is possible concerning the relative probability of the various theories that have been advanced concerning the constitution of the electron. That is, as to whether an electron is a rigid sphere of negative electricity or a sphere that is deformable with change of volume or deformable without change of volume. The conclusion which Kaufmann reached in 1906 was that the rigid electron or the electron that is deformable without change of volume equally satisfy his measurement. To distinguish between them would require a greater accuracy than has hitherto been attained. The whole question as to the possibility of an electron whose shape is not constant arose from the failure to observe any optical phenomenon that is dependent upon the motion of the earth through the ether, provided the source of light is terrestrial. Lorentz has shown that if a contraction takes place in the direction of motion and no change at right angles thereto, that no effect can be perceived by an observer moving with the apparatus. This whole question bristles with difficulties and is still under discussion. This much is certain, the inertia of an electron is all electrical inertia.

Combining this fact with the knowledge derived from the study of the Zeeman effect, that there are electrons in the atoms of mat-

ter, we have strongly suggested that all inertia is electrical. In other words, that atoms are aggregates of electrons.

J. J. Thomson has elaborately worked out the conditions of stability of groups of electrons supposed to be held together by the attraction of an atomic nucleus of positive electricity. He supposes the electrons in an atom to be arranged in rings and to be rotating around a center. He finds that if the number of electrons be increased that the number in a ring may increase to maximum, but that any further increase in the number of electrons will cause the formation of more rings. He shows that atoms built up of electrons whose numbers vary from 59 to 67 show a progressive change in properties, recalling the progressive change in a line of the periodic system of the elements.

This work of J. J. Thomson is the most ambitious attempt to explain the periodic system. Thus far it is merely an analogy.

Our knowledge of the structure of the atom is at the present time almost limited to the results of Stark and his school on the canal rays. Canal rays are observed in the space back of the perforated kathode. They are particles that carry a positive charge of electricity. They have masses of atomic magnitude and so are sharply differentiated from kathode rays, whose particles have masses but 1/1000 that of the hydrogen atom. Canal rays have been observed in many gases. And also the lines in the spectra show the Doppler effect, that is, are displaced in consequence of the motion of the centers of the emission of the light. The Doppler effect in the spectra of canal rays has been observed in the lines of mercury, nitrogen, carbon, oxygen, helium, argon, potassium, sodium, and lithium.

It appears from Stark's work that an atom-residue, positively charged, after having lost a single electron yields a spectrum consisting of series of doublets. If the atom has lost two electrons it emits light, the spectrum of which contains series of triplets. The band spectrum appears to be radiated from the complete atom that is electrically neutral.

From what has been thus far said it would appear that the electron theory has been elaborated to explain certain results of modern experimental physics. The idea has, however, been reached through another channel. Plank by applying general reasoning of the style adopted in thermodynamics and energetics in general to the theory of radiation has deduced the mass of the hydrogen

atom and also the charge that he denominates the elementary quantity of electricity. This determination of Plank of the mass of a hydrogen atom, and the charge constituting an electron, is to my mind one of the most remarkable intellectual results ever achieved. Drude speaks of them as being probably the most accurate values of these constants that we possess.

The fact that no optical phenomenon depending on the motion of the earth through the ether has ever been observed, provided the source of light is terrestrial has lead Einstein to formulate what he calls the principle of relativity. This principle assumes that no such phenomenon is possible. Plank and Stark combined in this principle with the principle of least action and deduced the most remarkable fact that the mass of a body at rest is equal to its internal energy divided by the square of the velocity of light. The smallest inertia with which we are acquainted is that of a single electron. This inertia multiplied by the square of the velocity of light gives us the value of the elementary quantity of energy. Enough has been presented to show how fundamental the electron theory has become and what a wide range of phenomena are correlated by its application. The theory seems destined to play an ever expanding role in the science of physics and gives promise of profoundly influencing philosophic thought.

FELDSPAR DEPOSITS OF MAINE.

The commercially important feldspar deposits of Maine all belong to a single type of rocks known to geologists as pegmatites. These are coarse-grained rocks which as a rule have the composition of granite, their principal constituents being feldspar, quartz, and mica, other minerals occurring in them in subordinate amounts.

Practically all the feldspar mined in Maine is used in pottery manufacture, its main application being as a constituent in both body and glaze in true porcelain, white ware, and vitrified sanitary ware, and of the slip (underglaze) and glaze in so-called "porcelain" sanitary ware and enameled brick. Small amounts of very pure spar, carefully hand-picked, are occasionally shipped for use in the manufacture of artificial teeth. Much interest has recently been aroused in the use of potash feldspar for fertilizing purposes. Experiments by the Agricultural Department have shown that certain plants are capable of readily decomposing feldspar that has been ground to the fineness now usually demanded in the pottery industry (200 mesh and finer), and experiments are now being made by that Department to determine what plants are benefited by the use of feldspar.

In the course of cöoperative investigations between the Maine State

Survey Commission and the United States Geological Survey, E. S. Bastin of the National Survey devoted some time to a study of the Maine pegmatites, and his report on the geographic distribution, geologic occurrence, origin, characters, uses, methods of mining and manufacture, and commercial availability of the feldspar is published by the Survey as part of its annual economic bulletin, No. 315. The principal quarries in Sagadahoc, Androscoggin, and Oxford counties are also briefly described. Numerous other quarries in Maine which have in the past produced feldspar and quartz were visited, and these will be described in the final report on the pegmatitic rocks, new material for which will be collected by Mr. Bastin in the course of his field work this summer. Meantime the paper in Bulletin 315 is available for distribution and can be obtained by applying to the Director of the Survey at Washington, D. C.

ESTIMATING THE COST OF AN ELECTRIC PLANT.

In calculating the cost of an electric power plant, it is of course necessary to take in account the probable life of the plant, so as to make a correct yearly reduction for depreciation. This is often more or less guess work on the part of the constructor or owner, and it may therefore be interesting to see a table from a recent issue of "Zeitschrift des Perines deutscher Ingenieure." The figures given are those used by two English experts, two English public corporations, and to series of figures from German technical publications. Conditions in this country would hardly differ enough from those of Europe as not to make these figures valuable for America.

Years of life for	Robert Hammond.	J. F. C. Snell.	Local Gov't Board.	L. Canby Council.	German.	Numbers.
Buildings	60	60	30	50	66	100-150
Boilers	20	20	15	20	15	10- 15
Steam engines	20-25	25	15-25	20	20	20- 25
Steam turbines	—	—	—	—	20	——
Gas engines	—	—	—	—	17	——
Water turbines	—	—	—	—	22	20 -30
Dynamos	25	25	20	20	20-22	18 -30
Storage batteries	15	10	5-7	20	10	5-10
Transformers	15	20	15	20	—	30
Switch boards	20	20-25	15	20	15	15
Conductors	25-30	15-60	12-15	12-50	25	10 -30
Electric meters	10	15	5	10	—	——
Arc lights	10	15	7-10	—	—	——

W. L.

STRENGTH OF RED AND YELLOW DOUGLAS FIR BRIDGE STRINGERS.

The terms red and yellow fir are not thoroughly defined. By some, only close-grained, bright yellow sticks are designated yellow fir, and all other sticks called red fir; while others call only close-grained sticks of a pronounced red color red fir and all other material yellow fir. Both red and yellow fir are secured from the same species, Douglas fir, and often from the same tree.

An analysis of the strength tests made by the Forest Service on Douglas fir bridge stringers is shown in the attached table. Those stringers were graded according to the export grading rules of the Pacific Coast Lumber Manufacturers' Association, and in the table are grouped by grades. In classifying the stringers according to color all timbers of a reddish tinge were called red fir and all of a yellowish tinge were called yellow fir. The rings per inch shown in the table indicate that yellow fir is of slower growth than red fir. It also ranges higher in grade. Of the 94 yellow fir stringers tested 47.8 per cent. were selects, 40.4 per cent. were merchantables, and 11.8 per cent. seconds. Of the 162 red fir stringers tested 29.8 per cent. were selects, 43.8 per cent. were merchantables, and 26.6 per cent, seconds, but, grade for grade, these tests show that there is practically no difference in the strength and stiffness of red and yellow fir in bridge stringer sizes.

STRENGTH OF RED AND YELLOW DOUGLAS FIR BRIDGE STRINGERS.

(Yellow fir expressed in per cent. of red fir.)

Kind of fir. Grade.	No. of tests.	Rings per inch.	Per cent. moisture.	Weight per cu. ft. in pounds As tested.	Weight per cu. ft. in pounds Oven dry.	Fibre stress at elastic limit. Lbs. per sq. in.	Modulus of rupture. Lbs. per sq. in.	Modulus of elasticity. 1,000 Lbs. per sq. in.
Red Select....	48	10.3	29.6	38.2	29.5	4,427	6,974	1,645
Yellow Select..	45*	17.5*	87.0	94.0	97.0	101	96	100
Red Merch....	71	9.0	29.7	35.9	27.7	4,056	6,019	1,534
Yellow Merch..	38*	16.4*	90.0	97.0	99.0	101	102	97
Red Seconds..	43	7.5	27.4	35.7	28.0	3,674	4,923	1,319
Yellow Sec'ds.	11*	14.5*	98.0	104.0	105.0	99	106	98

*Not expressed in per cent.

—(U. S. Dept. of Agriculture—Forest Service.)

INVESTIGATION OF CENTRIFUGAL PUMPS.

The recent construction of the new Hydraulic Laboratory at the University of Wisconsin has given opportunity for investigation along various lines of hydraulic engineering. The laboratory is located on the shore of Lake Mendota, which furnishes an abundant supply of fresh water. In its construction, two main ideas have been kept in view. First, to construct a laboratory that will give to all students of hydraulics a practical knowledge of the experimental conditions on which the established laws are based, and also a practical knowledge of the actual application of such hydraulic laws. Second, to afford opportunities for advanced students and for hydraulic engineers to undertake research work in lines where the experimental work has been limited or unsatisfactory. With both objects

in view, the construction of the laboratory has been on such lines as will admit of experiments of such magnitude that the unknown factors can be determined with a high degree of certainty, and so that the influence of various changes of condition can be differentiated with a reasonable degree of accuracy.

Among the large number of subjects which have not been satisfactorily covered by past experiments is the subject of centrifugal pumping machinery. This subject has been quite thoroughly discussed from the theoretical side, but most of such discussion has been based on insufficient data, or data which has been too complicated or too greatly obscured by unknown and possibly controlling factors.

The University of Wisconsin, through the department of Hydraulic Engineering, is endeavoring to supply the engineer, manufacturer and user knowledge concerning this type of machinery. The first bulletin on the subject, entitled "Investigation of Centrifugal Pumps. Part I—A Discussion of the Theory of the Centrifugal Pump and Tests of a Six-Inch Vertical Centrifugal Pump," has just been issued by the University.

Referring to the theory of the centrifugal pump, the bulletin discusses the general theory as ordinarily given for deriving the theoretical head developed by the impeller of a centrifugal pump, and shows how the various conflicting formulæ ordinarily given are essentially the same in result.

The experiments with the six-inch vertical centrifugal pump were arranged specially to investigate the effect on the discharge and efficiency, on the number and shape of the vanes of the impeller of the pump. For this purpose the impellers to be compared were made of the same general size so as to be easily placed in the same pump casing, while the number and shape of the vanes used was radial, and radial with curved entrance, while the number of vanes for each shape was varied, being six, twelve and twenty-four in number. The form of water way between the vanes was also varied by increasing the thickness of the outer ends of the vanes. The comparison of the results of the experiments thus show the effect on discharge and efficiency of the pump of practically all possible modifications of the simple radial vane. Additional experiments are now being made which will show the effect on discharge and efficiency of curving the vanes of the impeller both forward and backward, and also of varying the form of the pump casing.

The importance of the subject is such that the investigation has been laid out on broad lines and will last several years. It is hoped that the results of the investigation, when completed, will be of material aid to a thorough understanding of the subject.

The general scope of the investigation has been laid out by Daniel W. Mead, Professor of Hydraulic and Sanitary Engineering, while the details of the investigation and writing of the bulletins have been performed by Mr. C. B. Stewart, C.E. Copies of the first bulletin, University Bulletin, No. 173, may be obtained by addressing the Secretary of the Board of Regents of the University of Wisconsin, Madison, Wisconsin. Price, 50c, post paid, to non-residents of the State of Wisconsin.

FOREST SERVICE REDWOODS OF CALIFORNIA.

The large resources of the Pacific Coast redwood forests have been little used up to the present time. Until recently this timber only has use locally, but now it has become a competitor of many woods in the Eastern markets. It is being much used in the East for shingles instead of cypress, and to some extent for flooring, siding, laths, and finishing work. There is reason now to believe that its field of usefulness as a structural material will become extensive in the East also. Apropos of this situation the following recent letter is significant:

"U. S. Forest Service, Berkeley, Cal.

DEAR SIRS:—We very much desire that the U. S. Forest Service, at its earliest convenience, will make a comprehensive study of the physical and mechanical properties of redwood lumber.

The very many inquiries from parties actively engaged in construction work that are now constantly being made for reliable information concerning redwood, only emphasizes the need of the results of the official study of its properties that we now most respectfully request may be made.

Hoping for your early and favorable consideration, we are,

Very truly,

(Signed) REDWOOD ASSOCIATION,
By A. B. Wilcox.

The Forest Service has decided to comply with the request of the Redwood Association. The work will be done at the testing laboratory at Berkeley, Cal., in cöoperation with the University of California, and it is thought that the results of these tests will prove of great interest to the users of lumber throughout the United States.

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(Stated meeting held Wednesday, March 18, 1908, 8 p.m.)

Engineering Practice as Applied to the Fueling Equipment of Power Houses.

BY HARRY P. COCHRANE.*

In the manufacture of any product the primary object is production with the least expenditure of money, due importance being given to the reliability of the product.

The operating expense account of any plant depends a great deal upon its mechanical equipment.

For many years the energy of power station engineers was mainly devoted to perfecting the arrangement of engines, generators and electrical apparatus, often neglecting the more important, though less showy, boiler-room equipment. A larger percentage

*Chief of Estimating Department Link-Belt Co.

of saving can be made by a proper attention to the design and operation of the boiler room than in any other department of the station.

The cost of power is an important factor, sometimes amounting to more than all other operating costs combined, and depends upon the cost of fuel; the cost of fuel in turn, upon the purchase price and method of handling.

The method of handling depends a great deal upon local conditions. Whether an outlay for mechanical handling is justified depends upon the size of the plant, but, sometimes, the matter of convenience or space may be a factor.

The transportation of coal from stock to ash heap via boiler room cannot be done in one place the same as in another location, with the same degree of efficiency and at the same cost. The location and the surroundings are the controlling factors.

Is expenditure for mechanical handling justified, and will the amount to be saved show as a profitable return on the investment?

Some plants are so small and convenient that one man can care for the boilers and do the firing.

(From a Report made to the Steam Users Association.)

"Under average conditions one man can run an engine and fire up to ten tons per week.

"For thirty tons it requires an engineer, one day and one night man. This is for about a 200 H.P. plant.

"For a 500 H.P. plant it would require an engineer, two day men and one night man." (This information was compiled from reports of four hundred members.)

"From investigation of six hundred (600) small plants the average cost of handling was 48c per ton, with a maximum of 71c, and a minimum of 26c per ton."

"Where coal was moved by wheelbarrow the cost was 1.6c per ton for the first five yards, and 1c per ton for each additional yard."

Mechanical stokers are almost universally used in power stations on account of the increased efficiency over hand-fired furnaces and the reduced cost of operation.

Equally as good results have been obtained with hand-fired furnaces by careful and intelligent firemen, but the trouble is that such firemen are not plentiful, and it is extremely difficult to secure men who will produce good results all the time. For this

reason the fuel economy will be better where the firemen are assisted by some form of mechanical stoker.

When the coal is deposited in the boiler room so that it requires but one shovelling to the furnace, one man can care for the boiler, coal and ashes of a 400 H.P. plant. If the coal requires two handlings a fireman and helper are required for each battery of 500 H.P. Where automatic stokers are used and coal is fed to the hoppers by gravity, one man can care for 2000 H.P. of boilers.

The cost of mechanical handling varies according to conditions and the size of the plant. The smaller the plant the greater the cost per H.P., both for installation and operation, while for the the larger plants the labor cost for the mechanical transferring of coal from cars to stokers is as low as 2c per ton.

In reply to the query of "The amount of saving accomplished by the installation of machinery," one manufacturer states "As near as we can approximate, our saving (including repairs, depreciation and interest on investment), is about $3,500.00 per year."

The cost of this plant was $16,950.00. This shows a return of $23\frac{1}{2}\%$ on the investment.

Another case: Where a 4000 H.P. plant with coal dumped from trestle alongside of building, required eight men to stoke and eight helpers on each turn. The labor cost amounted to $18,-200.00 per year; when the plant was equipped with mechanical stokers and coal handling machinery, including an overhead bin at a cost of $26,000.00, the labor cost was reduced about $13,400.00 per year. This, with the interest, depreciation, repairs, etc., deducted, showed a return on the investment of about 37%.

Other cases might be cited where the returns showed as high as 75 to 80 per cent. on the investment, but such cases are rare. However, 20 to 40 per cent. returns on the investment are generally the case.

As conditions for every plant differ, no fixed solution can be offered, but each case must be treated as a separate problem.

The type of machinery and method of handling depend upon—

The size of plant.

The kind and size of coal.

The rate or capacity at which coal is to be handled.

The location of the delivery point.

Whether reserve storage, and how much.

Where the coal is small, as well as the capacity, the simplest method consists of—

Track hopper.
Elevator.
Conveyor.

If the coal is lumpy, and capacity *not* an important factor, a grating (with about 6″ sq. openings), is placed between the dump and the elevator. The large lumps are broken on this grating.

Where bituminous coal is handled and stored in an overhead bunker, the coal should be crushed before elevating.

Assuming that the size of plant justifies the installation of mechanical handling, then—

The design of the machinery should embody

Simplicity.
High efficiency.
Durability of construction.
Immunity from breakdown.
Low first cost.
Low cost of operation, and
Low cost of maintenance.

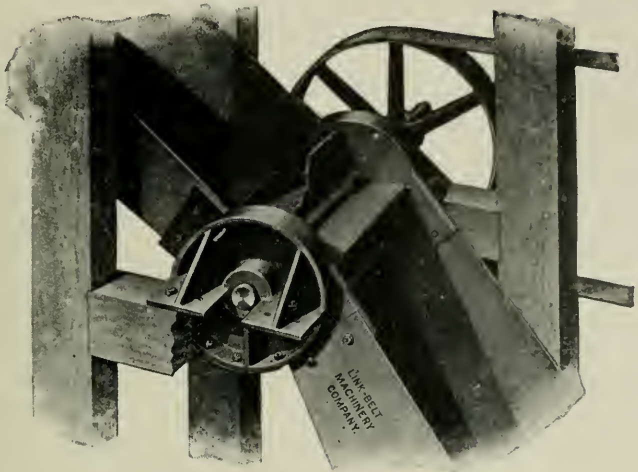
The receiving hopper should be constructed so that the coal will run freely down the corners, and the opening of such a size that the coal will not jam. If the coal is of small size, with no large lumps, it can be controlled by the use of a slide gate, but if large lumps are to be handled an opening of sufficient size would permit the coal to flow faster than the machinery could take it away, and could not be controlled by a gate without the constant supervision of an attendant.

Several automatic feeding devices have been designed to eliminate this annoyance and regulate the flow, among which are the—

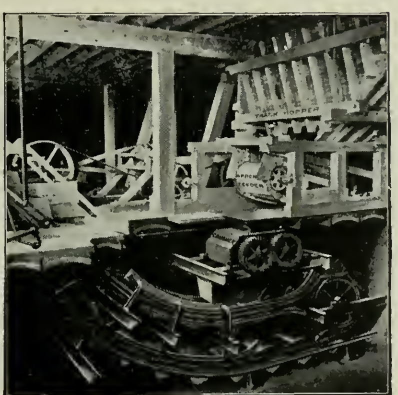
Roll Feeder;
Apron Feeder, and
Reciprocating Feeder.

The *roll feeder* was first used for handling ore, and was found very efficient. It consists of a drum with angles fastened to the outer surface. This requires considerable head room, and a modification consists of a cast-iron drum, with pockets or blades radiating from the sleeve, (see cut 1813).

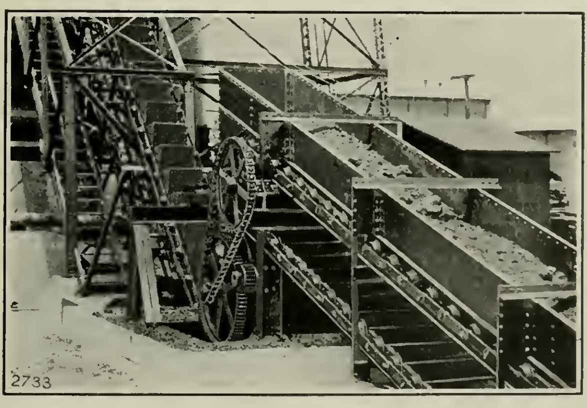
The *apron feeder* consists of two chains with overlapping steel slats forming a continuous belt. This form is best where a



(1813) Roll feeder.



(1472) Apron feeder. 25th Ward Gas Works, U. G. I. Co., Philadelphia.

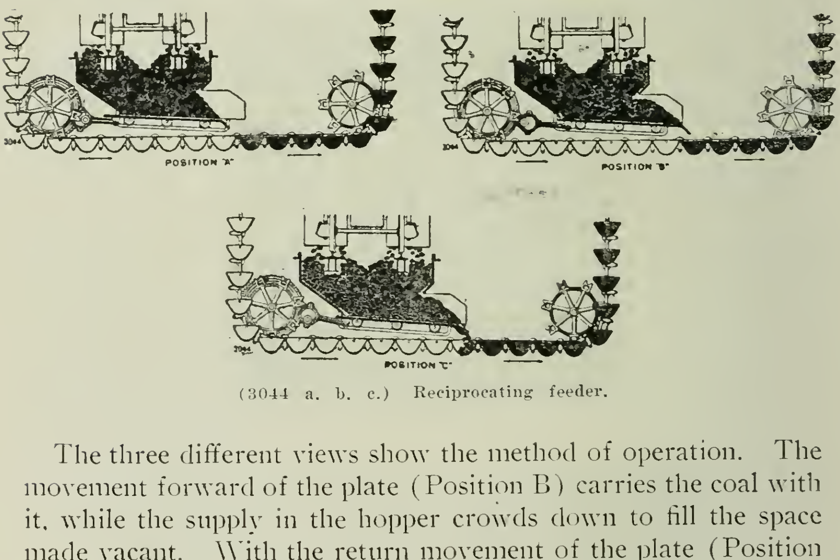


(2733) Apron feeder as conveyor at Semet Solvay Co., Geneva, N. Y.

steady, continuous feed is required (see cut 1472), or where the hopper is at a distance from the elevator, the feeder acting as a conveyor (see cut 2733).

The *reciprocating feeder* is much simpler and cleaner, there being no spill from damp, sticky coal. It is used where an intermittent feed is required. It can be timed to operate with spaced buckets, discharging the proper amount in each bucket as it passes the feeding point (see cuts 3044, a. b. c.)

It consists of a flat plate mounted on rollers and operated by an eccentric connected with the elevating machinery. The amount delivered is regulated by the throw of the plate. The mechanism is so made that this throw can be quickly adjusted, thus increasing or decreasing the amount delivered by each reciprocation.



(3044 a. b. c.) Reciprocating feeder.

The three different views show the method of operation. The movement forward of the plate (Position B) carries the coal with it, while the supply in the hopper crowds down to fill the space made vacant. With the return movement of the plate (Position C) the material is forced over the end into the bucket (or crusher, if crushing is necessary). When the plate is in its innermost position the outer end should be slightly beyond the line of repose of the coal.

Provision should be made for the installation of a crusher. If fine or crushed coal is received it can be by-passed around the crusher.

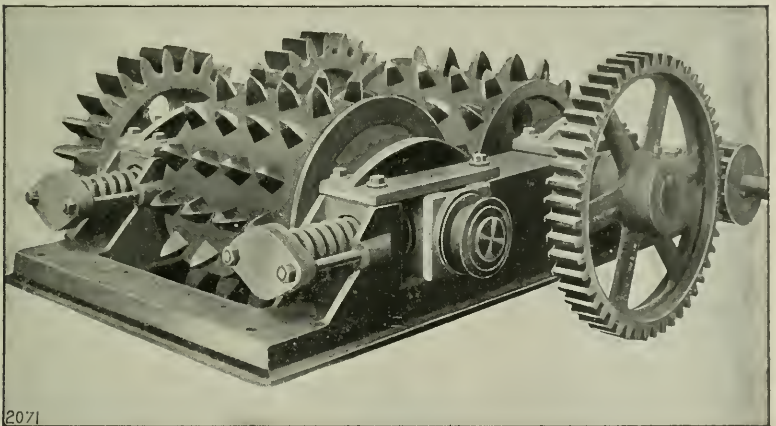
As it is not always possible to obtain small coal the crusher will be found necessary, and should be placed as near the receiving

point as possible, so as to avoid the use of large machinery to handle the large lumps of coal.

The crusher (see cut 2071) should be of a very rugged design, and provided with spring release, so that should obstructions, such as wood or iron, get into the rolls the latter would spread sufficiently to allow the foreign materials to pass between them without danger of smashing the frame.

CRUSHERS.

Crusher Size.	Tons Cap.	Max. Lumps.	Crushed to.	H.P. Reqd.	Speed Rolls.	Speed Ctr.
20″ x 24″	30	12″	2½″	5 : 7½	40	150
28″ x 24″	50	R. of M.	4 ″	7½ : 10	56	200
28″ x 36″	85	"	4 ″	10 : 15	72	200



(2071) Crusher with spring release.

From this stage on the machinery may differ, according to the requirements, and may be divided into two classes:—

A. An elevator with separate conveyor, or

B. A combined elevator-conveyor.

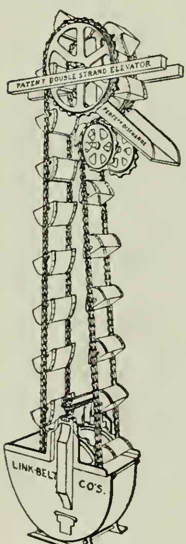
A. *Elevators* are of four types, namely:—

1. Centrifugal Discharge.
2. Perfect Discharge.
3. Continuous Bucket.
4. Skip Hoist.

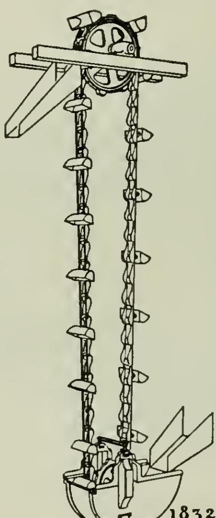
1. Centrifugal Discharge Elevators (see cut 1832), consist of a single strand of chain or belt with buckets attached at intervals,

and run at high speeds of from thirty to forty revolutions of the head shaft, or from 200 to 400 feet bucket speed. The coal is thrown out and has considerable breakage, with a great deal of dust.

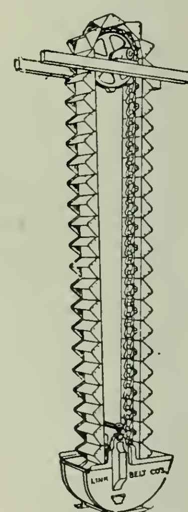
2. *Perfect Discharge* Elevators (see cut 1831), consist of two strands of chain with buckets at intervals between. A pair of idler wheels set under the head wheels cause the buckets to be completely inverted and make a clean delivery into the chute at elevator head. The speed is much slower than the Centrifugal Elevator.



(1831) Perfect discharge elevator.



Centrifugal discharge elevator.


(1829) Continuous bucket elevator.

3. *Continuous Bucket* Elevators (see cut 1829), are of either single or double strand chains, with buckets attached continuously. Each bucket after passing over the head wheel acts as a chute for the following bucket. The speeds are slow—from 90 to 200 feet per minute.

4. *A Skip Hoist* consists of a large bucket or skip connected to a hoisting drum by means of wire ropes. The skip runs between guides or tracks so arranged that at the top the bucket is inverted and the load dumped. This machine requires an attendant at the

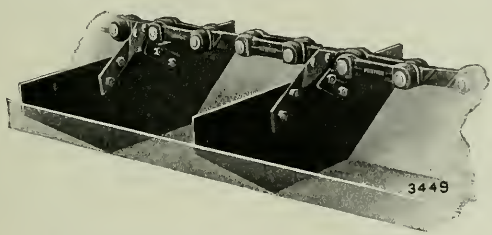
loading point. When an electric hoist is used an automatic reverse attachment is employed, so that by throwing in a switch the skip will rise, discharge its contents, and then automatically return to the loading point.

Conveyors may be Screw, Scraper, or Belt.

Screw Conveyors consist of a helical steel flight mounted on a shaft (solid or pipe), and run in a U shaped trough. These come in sections from eight to twelve feet long and from nine to eighteen inches in diameter. The capacity ranges from ten to thirty tons per hour with speeds of about sixty revolutions per minute.

It is not advisable to use this form of conveyor for coal, as it will only handle the smaller sizes, and is easily damaged by any foreign substance of unusual size or shape.

Flight Conveyors consist of a trough of any desired cross section, either single or double strand of chain carrying scrapers or flights of approximately the same shape as the trough. The flights push the coal ahead of them to any desired point, where it is discharged through openings in the bottom of the trough.



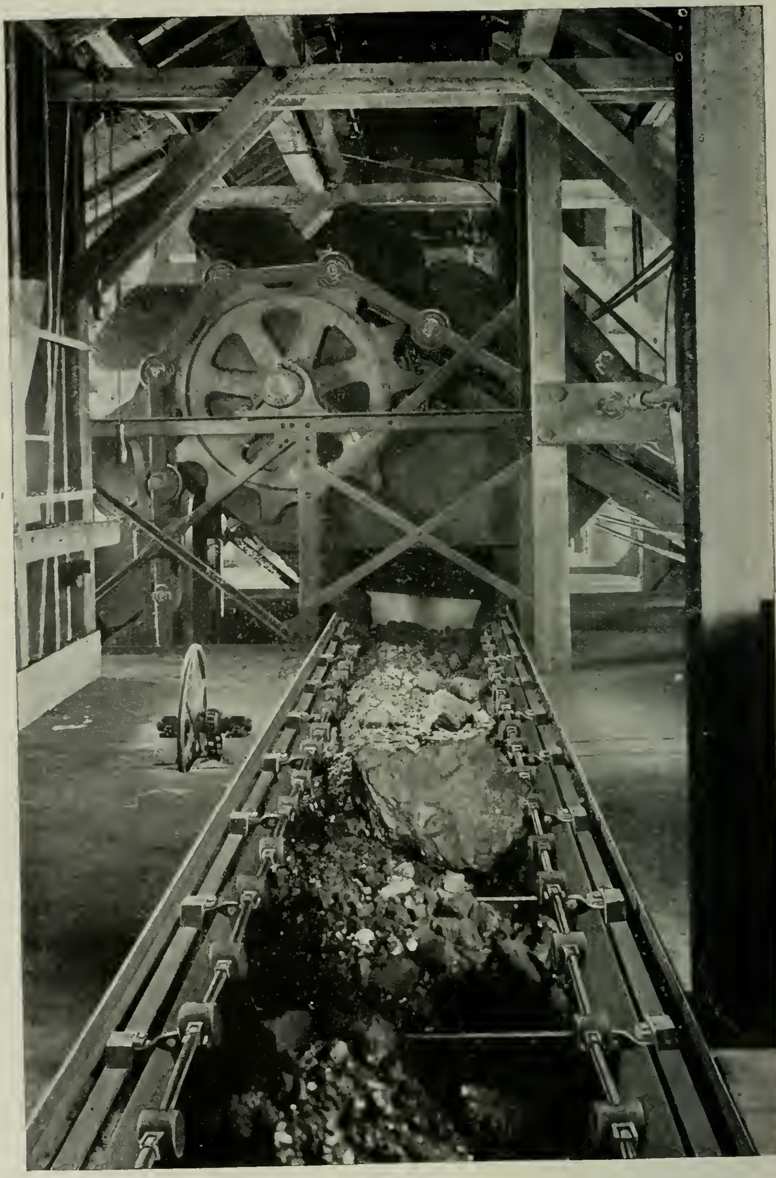
(3449) **Plain flight conveyor—maximum chain.**

Flight Conveyors are of three types:—

Plain Flight.
Suspended Flight.
Roller Flight.

The *Plain Flights* (see cut 3449), are attached to the chain, and drag along the bottom of the trough. Conveyors of this type are of low first cost, and useful when noise is not objectionable, but require more power than the other two types.

The *Suspended Flights* (see cut 1555), are attached to cross bars having wearing shoes at the ends. These shoes slide on angle iron tracks on each side of the conveyor trough. The flights do



(1555) Suspended flight conveyor at Erie Railroad Co., Jersey City, N. J.

not bear on or touch the trough at any point. This type is of higher first cost than the scraper, but takes about one-fifth less power, and is used where quietness of operation is a consideration.

The *Roller Flight* (see cut 1704), is similar in construction to the suspended flight, except that rollers replace the wearing shoes. It is of highest first cost, but has the advantages of low power consumption (about two-thirds that of scraper), and noiseless operation.

(1704) Roller Flight Conveyor—Monobar Chain. Allegheny City Water Works, Allegheny, Pa.

CAPACITY OF FLIGHT CONVEYORS IN TONS PER HOUR AT SPEED OF 100′ PER MINUTE.

Material 50 lbs. Per Cubic Foot. Flights Spaced 24″ C.

SINGLE STRAND.

Size of Flight	Inclination of Conveyor 0°	10°	20°	30°
4″ x 10″	22	18	14	10
4″ x 12″	28	24	18	13
5″ x 12″	34	28	22	16
5″ x 15″	46	40	31	22
6″ x 18″	60	49	40	31
8″ x 18″	90	72	57	48
8″ x 20″	105	84	66	56

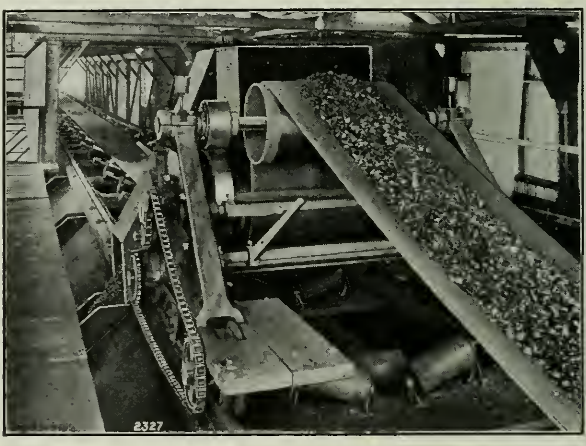
DOUBLE STRAND.

Size of Flight	Inclination of Conveyor 0°	15°	30°	45°
8″ x 16″	82	62	41	27
10″ x 20″	129	97	63	43
10″ x 24″	154	116	77	52
12″ x 30″	222	167	111	75
12″ x 36″	270	203	135	90
12″ x 42″	315	226	157	105
12″ x 48″	360	272	180	120

Belt Conveyors (see cut 2327), consist of head and foot drums or pulleys connected by an endless flexible apron. This apron is, usually, of rubber or cotton belt. The intermediate supports for

the belt consist of idler pulleys spaced from 4 to 5 feet on the carrying side, and about 10 feet on the return.

The carrying idlers are so shaped that the belt is troughed for its entire length. When properly designed, and under certain conditions, belt conveyors prove highly satisfactory, and are better in some cases than any other type of conveyors. To give the best and most lasting results the belt should not be excessively troughed, and the idlers thoroughly lubricated. The speeds vary from 200 to 800 feet per minute, and have capacities as follows:



(2327) Belt conveyor at Maryland Steel Co., Sparrows Point, Md.

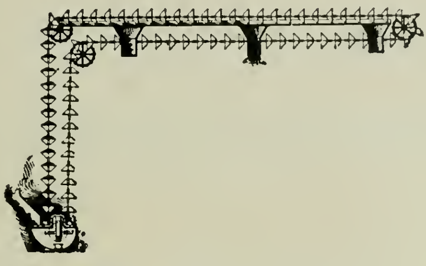
CAPACITIES BELT CONVEYORS IN TONS AT 50 LBS. CU. FT.

Width of Belt.	*Velocity of Belt Feet per min.* 200	300	400	500	600
14″	24.5	36.7	49.	61.3	73.
16″	32.	48.	64.	80.	96.
20″	50.	75.	100.	125.	150.
24″	72.	108.	144.	180.	216.
30″	112.	168.7	225.	281.	337.
36″	162.	243.	324.	405.	486.

NOTE.—At 400′ per min. the capacity in tons per hour (for coal at 50 lbs. per cu. ft.), is equal to one-half the width of belt squared. $\left(\frac{W}{2}\right)^2$ = tons per hour.

The limiting angle for belt conveyors is about 20°, as above this the coal will slide or roll back and spill, even at 20° the feed must be steady, so that the material forms one continuous pile along the center of the belt.

Belt conveyors have high carrying capacity and low power consumption, but are relatively high in first cost and repairs. Where discharge at intermediate points are required a *traveling tripper* or dumper is used. This can be hand propelled or power driven, the power being supplied by the belt.

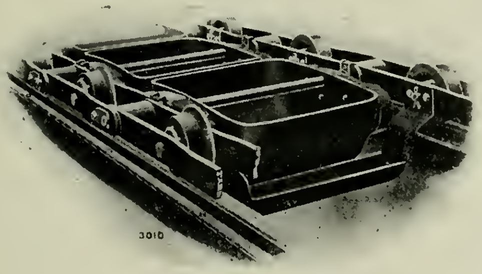


(3195) Gravity discharge elevator conveyor.

H.P. OF 100′ CONVEYOR AT 100′ PER MIN. FOR COAL.

Inclination.	Size of Belt. 14″	16″	20″	24″	30″	36″
0°	.25	.31	.42	.57	.88	1.20
5°	.35	.45	.67	.97	1.57	2.31
10°	.45	.59	.92	1.37	2.26	3.42
15°	.55	.73	1.17	1.77	2.95	4.53
20°	.65	.87	1.42	2.17	3.64	5.64

NOTE: Add 20% to H.P. if Tripper is used.



(3010) Pivoted buckets with retrievers.

B. Combined Elevator Conveyors are of the following types:

1. Gravity Discharge.
2. Rigid Bucket Carriers.
3. Pivoted Bucket Carriers.

1. The *Gravity Discharge* type (see cut 3195), consists of

V-Buckets rigidly attached at intervals between two strands of chain (preferably roller). After passing around the turn wheel from the vertical to the horizontal, the buckets act as conveyor flights and convey the coal similar to a scraper conveyor. This is the cheapest form of combined elevator-conveyor, and is economical of power.

H.P. OF V-BUCKET ELEVATOR-CONVEYOR AT 100′ P.M.

AND CAPACITIES.

Size of Bucket L. & W.	12″x12″		16″x15″		20″x15″		24″x20″		36″x20″	
Spacing of Bucket	18″	36″	18″	36″	18″	36″	18″	36″	18″	36
HP for ea. 10′ Vert. Lift	.46	.23	.9	.45	1.06	.57	2.4	1.2	3.8	1.
HP " " 100′ Hor. Empty	1.2	.9	1.5	1.1	1.6	1.2	2.2	1.5	2.4	1.6
HP " " " " Anth.	2 5	1.5	4.0	2.3	4.7	2.8	8.8	4.8	12.4	6.6
HP " " " " Bit.	3.2	1.9	5.3	3.0	6.5	3.6	12.3	6.6	18.	9.
Capacities level full tons per hour	31	15.5	61.4	30.7	78	39		82.5		12

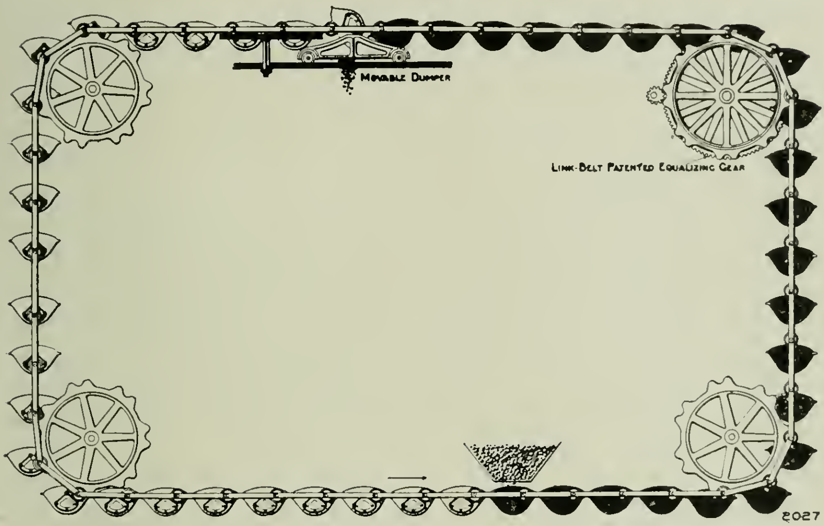
2. *Rigid Bucket* carriers are made of specially shaped buckets carried between two strands of long-pitched steel roller chain. The buckets are shaped so as to carry coal around three sides of a rectangle. To discharge the load it is necessary to temporarily invert the bucket by passing through a *dumping carriage*.

3. *Pivoted Bucket* carriers consist of malleable or wrought steel buckets suspended from shafts running between two strands of long-pitch chain. The buckets are arranged so that their adjacent lips are close together or overlapping. Carriers in which buckets do not overlap should be fitted with auxiliary buckets or retrievers arranged in such a manner as to catch the spill (see cut 3010), which falls between the lips at the loading point. and designed so as to return the coal thus caught to the pivoted buckets as the conveyor changes from the horizontal to the vertical run. The overlapping bucket (see cut 2027), is pivoted from an extension arm of the inside chain links. On account of this when the buckets pass around the corner turns they describe a larger curve than the chain proper, and separate to such an extent that there is no interference between the overlapping lips, and are at all times, except when discharging, in a natural horizontal position. Pivoted buckets will carry around four sides of a rectangle, and are dumped on the horizontal run over a cam dumper. The turns under stress should always be over wheels, and not around curves.

CAPACITIES AT 40′ PER MINUTE.

Size.	Max. cap. Bucket lbs.	Tons per hr. at .8 max.
24″ x 18″	84	40
24″ x 24″	112	54
24″ x 30″	140	68
24″ x 36″	163	82
24″ x 42″	196	96
24″ x 48″	224	110

Maximum Speed 60′ per min.



(2027) Pivoted buckets—overlapping type.

H.P. OF PIVOTED CARRIERS.

Place of Installation.	Path. Hor.	Path. Ver.	Coal Handled.	Speed.	Cap. Tons.	H.P. Empty.	H.P. Full.
Rockingham L. & P. Co., Portsmouth, N. H.	150′	52′	Bit. Slack.	38′	30	3.3	5
Washington Navy Yard	103′	33′	Crushed Bit.	46′	30	3.0	5 *
Penna. Railroad, Renovo	64′	49′	" "	45′	33	2.7	4.6
Penna. Railroad, Altoona			" "	46′	33	2.4	5.3
Wanamaker Power House	75′	114′	Buckwheat	42′	40	6.2	15.4*
Brooklyn H'ts R. R. Co.	380′	110′	"	54′	92.3	9.9	21 *

*Drives Reciprocating Feeder.

OVERHEAD STORAGE.

The storage of coal overhead enters very largely and vitally into the cost of handling:

1. Convenience.

2. It avoids the expensive wheeling in case of a breakdown of the machinery.

3. Avoids running the machinery continuously.

4. Coal under cover will not freeze in winter, and clog the supply pipes to the boilers.

5. Sometimes cheaper to store overhead than to use valuable ground space.

6. As distinguished from vault or outside storage it is cheaper to build steel bins than masonry pits.

The amount of this overhead storage depends a great deal upon local conditions, and whether coupled up with an outside storage.

For power, lighting and pumping stations where the results of an enforced shut-down, through lack of fuel, would be disastrous, the capacity of this storage should be of sufficient amount to supply the wants during the interruption of the supply. For ordinary conditions this should be of sufficient amount to take care of a five- to ten-days' run when the plant is working at full capacity.

The smaller overhead bins are, usually, constructed of steel.

The cheapest type of steel bin is the "Berquist Suspended" Bin (see cut 2344), and is made in sizes from one ton per foot capacity up.

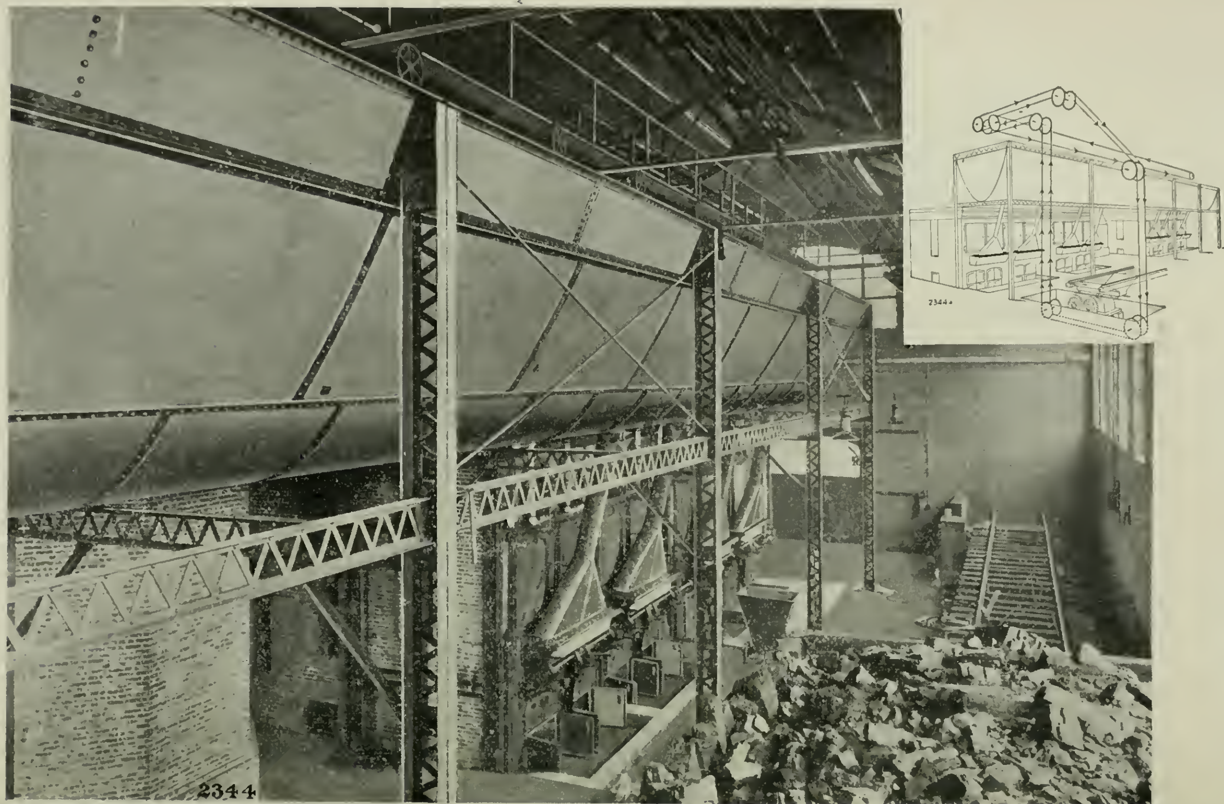
COMPARISON OF WEIGHTS OF DIFFERENT SHAPED BINS.

Place of Installation.	Total Cap. Tons.	Cap. per ft. Tons.	Total Wght. Steel.	Weight without Spts.	Proportional. With Spts. Coal.	Steel.	Without Spts. Coal.	Steel.
Crucible Steel*	350	3	113.300	87,250	6.15	1	8	1
Morrison & Cass*	500	3	111,600	81.725	8.95	1	12.2	1
S. J. E.&T. Co.	76	1½	35.960	23,390	4.23	1	6.5	1
Raritan Cop. Co.	118	1¾	40.350	40.350			5.85	1

For the larger sizes, say above six tons per foot capacity, the usual construction is a combination of a steel skeleton with reinforced concrete floor and sides.

Spouts from overhead storage to boilers should be of ample size to permit the passage of coal without clogging, and for

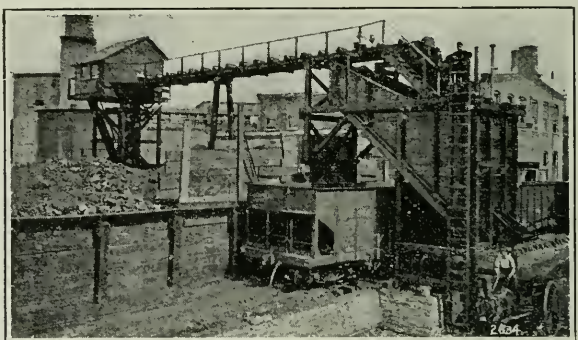
*Berquist Type.



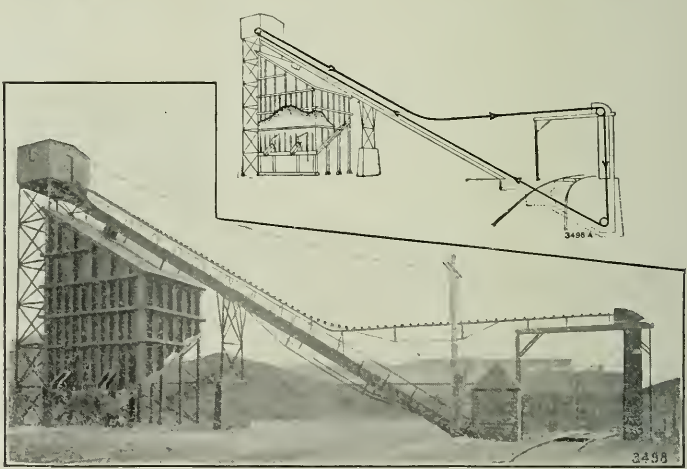
(2344) Boiler house equipment. Crucible Steel Co., Jersey City, N. J. Consists of 350-ton Perquist suspension bunker with elevator and conveyor for delivering coal to same and crusher for crushing coal, as it is automatically delivered from track-hopper by means of a Link-Belt reciprocating feeder. Machinery electrically driven. Capacity 40 tons per hour. Designed and constructed by The Link-Belt Co., Philadelphia, New York and Pittsburg.

crushed bituminous coal should not be less than twelve (12) inches in diameter.

Other forms of storage are the vault storage, where the railroad cars are run onto a trestle and dumped, and the independent bin along the front of the boiler house (see cut 1533). Both of



(2634) Outside storage—bituminous coal. Thomas Potter Sons & Co., Philadelphia, Pa.



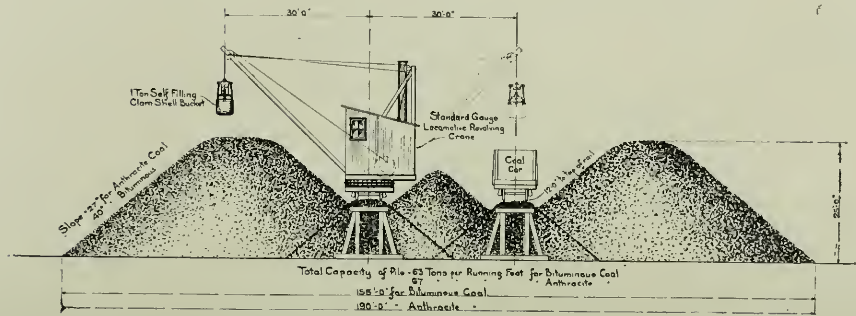
(3496) Outside storage—anthracite coal. Weideman Silk Dyeing Co., Paterson, N. J.

these types are common where the boilers are in a single line. The coal is shoveled to the boiler, or chuted to machinery which takes it direct to the stokers or small overhead bin.

For small plants a very efficient rig is the *Traveling Elevator*, but the cost of installation, including storage pit, foundations

PLAN OF COAL PILE & TRESTLES
FOR
10,000 TONS BITUMINOUS COAL

Total Capacity of Pile	Total Length of Pile in Feet. Bituminous Coal	Anthracite Coal
5000	110	125
7500	150	162
10000	190	200
12500	230	237
15000	270	274
17500	310	311
20000	350	350
Capacity of Pile per Running Foot	Bituminous Coal 63 Tons	Anthracite " 67 "



CROSS SECTION THROUGH BITUMINOUS COAL PILE

(2023) Trestle storage with locomotive crane.

(3533) Locomotive crane with central pit. Michigan Alkali Co., Wyandotte, Mich

and structural supports for track, will run much higher than an overhead bunker of the same capacity.

Ground or *Outside Storage* (see cuts 2634 and 3496).

This may be divided into two classes,—*Bituminous* and *Anthracite.*

The maximum depth at which soft coal is stored should not be more than twenty-five feet, and sometimes as low as fifteen feet, owing to its tendency to spontaneous combustion.

Trestle Storage, say twenty feet high, will stock out twenty tons of Bituminous and twenty-five tons of Anthracite coal per running foot of trestle. For a five thousand ton pile it requires about two hundred and fifty feet of trestle for Bituminous, and about two hundred feet for Anthracite. With an approach on a grade of five per cent. this would make the total length of trestle over six hundred and fifty feet. With the price per thousand feet b.m., including bolts at $35.00, the cost of a trestle twenty feet high would be $7.36 per foot, and the total cost would be about $4300.00, excluding foundations. Adding to this the cost of trackmaking would bring the figure up to about $5000.00.

Trestle Storage in connection with a locomotive crane (see cut 2023), reduces the amount and height of trestle, and 5200 tons can be stored in an area of 190′ x 125′ for Anthracite and 155′ x 110′ for Bituminous.

With a 35′ radius crane one man can handle 450 tons a day. Figuring for crane repairs, depreciation, interest, wages and power, the cost per ton would be from 1½c up to 2c. To this must be added the cost of trestle.

Another form of crane storage consists of a central dumping pit, with a circular track radiating from the pit.

With cranes of radii of 35′ to 80′ from 6000 to 40,000 tons can be stored in this way (see cut 3533). This is the cheapest storage system for large bodies of bituminous coal, and combines low cost of handling with low investment cost.

Another type is the *Bridge Tramway* (see cut 2408). This shows a 280′ span bridge equipped with a two-ton self-filling bucket. The bridge swings through an arc of 170° and commands a storage of 50,000 tons. If the circle was completed the storage would be over 100,000 tons. This type is also made with parallel traverse. Cut 2576 shows a combination of bituminous

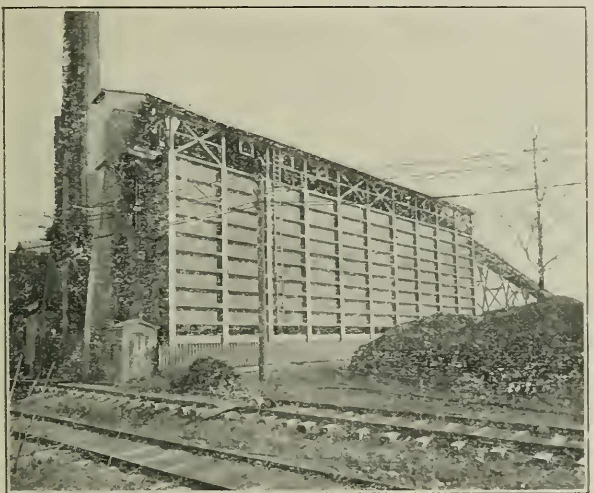
(2408) Bridge tramway. Maryland Steel Co., Sparrows Point, Md.

(2576) Dodge coal storage plant. N. Y. Edison Co., Shady Side, N. J. Bituminous and anthracite.

(3017) Dodge coal storage plant. Philadelphia and Reading Coal and Iron Co., Abrams, Pa.

and anthracite storage at the New York Edison Company, Shadyside, N. J., opposite New York City. The accessibility of this base of supply enables the company to meet the fueling demands of its various stations in New York and assures the continuity of their operation. Anthracite is delivered at the storage plant by either rail or water. Bituminous by water only.

The *Dodge System* was the first and is the most successful application of engineering practice in the storing of Anthracite coal. Its effectiveness is due to simplicity of design, mechanical efficiency, and the economy resulting from its operation. It



(1533) Bin along front of boilers. Penna. Mfg. Light and Power Co., Tacony, Philadelphia, Pa.

consists of a chain conveyor supported by a shear truss, constituting a trimming machine, which piles the coal without breakage, delivering it upon the ground or at the ascending apex of a pile as it is formed, and a pivotal or radial ground-conveyor, called a reloader, mounted on a steel frame, and power actuated in all its movements.

As usually arranged for open-air storage on levelled ground, two trimming machines and one reloading machine located between them constitute one group.

Cut 3017 is a general view of the 480,000-ton Bridgeport Transfer of the Philadelphia & Reading Coal & Iron Company,

at Abrams, Pennsylvania. The immense tonnage of this plant is divided into eight (8) piles, four on each side of a central railway system—each pile having a capacity of 60,000 tons. The stocking out capacity is 14,400 tons per day, and the reloading into cars of 10,000 tons per day of ten (10) hours.

THE JAPANESE INTERNATIONAL EXPOSITION.

Aoyama, one of the highest and most beautiful parts of Tokio, has been chosen as the site for the Grand Exhibition of Japan, to be held from April 1 to October 30, 1912. The exhibition grounds will cover a total area of about 290 acres. A road about 480 feet in width will be built, connecting the Aoyama parade ground and the imperial property, near by. Thus far a number of nations have sent their approval of the exhibition to the Japanese Government. The exhibition is to be held, not for the purpose of commemorating any historical event, but to show to the world the development and progress of Japan. The government has planned to spend $5,000,000 from the national treasury, and it is expected that the various provinces and municipalities will appropriate $5,000,000 more to the exhibition. The city of Tokio will contribute $2,500,000 as its share.—*Iron Age.*

A new coal field is being opened up near the coast of California, between San Francisco and Los Angeles, which is expected to have an important effect on the fuel supply conditions in that State. Unlike most beds in the State, which are lignitic in character, this one is an 18-foot seam of semi-bituminous coal. It is expected that several hundred tons of coal per day will soon be produced by these mines, and about 1½ miles of gangway have been opened up.—*Iron Age.*

A 24,000-h.p. steam turbine, which is probably the most powerful turbine for stationary service yet ordered, is reported to be under construction at the Mannheim Works of Brown, Boveri & Cie., for the Krupp steel works and blast furnace plant at Rheinhausen.—*Iron Age.*

Mechanical and Engineering Section.

(Stated meeting held Thursday, March 26th, 1908.)

Casting Pipes in Permanent Molds.

BY EDGAR A. CUSTER.

In the February issue of a magazine devoted to foundry practice, a writer in speaking of the limitations of molding machines made this statement: "A mold that molten iron would not destroy or one in which the evils of unequal heating and cooling would not show on the finished article, was as far removed as the Philosopher's Stone."

The purpose of this paper is to describe method and apparatus using permanent molds, that the hottest iron attainable from the cupola does not destroy, and produces cast-iron pipe in which the supposed evils of unequal heating and cooling not only do not appear, but do not exist.

So-called permanent molds are not new. For many years small iron castings have been successfully made in iron molds, and this without great detriment to either the casting or the mold. These castings, however, were invariably very small and were chilled to extreme hardness. Fortunately it was not necessary to machine them. This limited the use of such molds very materially. Some years ago the Latrobe Steel Co. cast car couplers in iron molds. Within a few months, an article has been published, describing a successful method of making brake shoes in this manner. These shoes weighed about twenty pounds each and with the exception of steel ingots and car couplers were the heaviest castings made in iron molds. So far as can be learned, this is about the extent of the art. It has been the dream of every foundryman whose trade requires a large number of duplicate castings, to make these castings in molds that would not

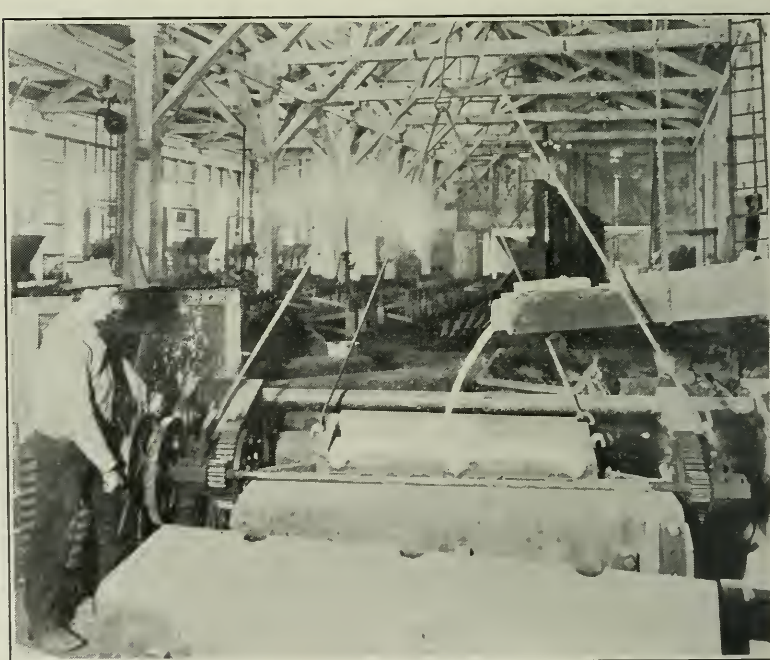
only survive the process, but would also produce castings that would be marketable and be easily machined.

THE METHOD RELATES ONLY TO SOIL, WATER OR GAS PIPE.

You are probably all familiar with soil pipe making. Iron flasks, a cope and drag, are rammed with sand over a metal pattern; a green sand core is introduced, and the cope and drag are clamped together. The pipe is then poured, with the pipe in a horizontal position, and after cooling, the pipe is removed from the flask and carried to the end of the floor where the cores are removed. Then it is carried to the cleaning room where the sand is rattled off, the gates and fins are removed, and after inspection it is ready for shipment. Altogether the pipe has to be handled ten times. In this process the loss is very great. So much depends upon the condition of the sand; it may be too wet or too dry; the molder may ram carelessly, or may pour his iron negligently, so that the foundry loss often reaches 12% to 15%. In summer weather the output is decreased 25% to 40%, due to the inability of human beings to stand the exacting and exhausting labor. Only one heat a day can be poured in any season. In fact, with very few improvements, and these relating mainly to cores, we are making soil pipe in precisely the same manner and with just as much labor per pipe as was the practice fifty years ago. It is true that the workman of to-day makes more pipe in one day than his grandfather did, but this is due more to the fact that the present-day workman is working by piece and has become infinitely more skilled in saving the seconds of time for each particular operation and avoiding the useless motions in performing them. Any process that would save the use of sand for the mold and would produce pipe that could be easily cut would of necessity be very desirable. If in addition it would obviate cleaning and chipping and could be run continuously night and day, it would very nearly meet the conditions of an ideal business. When experiments to discover and perfect such a process were undertaken, the first mold made was closely modelled from the flasks in use in the sand process. In fact, all the traditions of foundry practice were closely followed. The apparent danger of pouring molten iron into iron molds encasing a damp sand core, was considered to be serious, and the problem of disposing

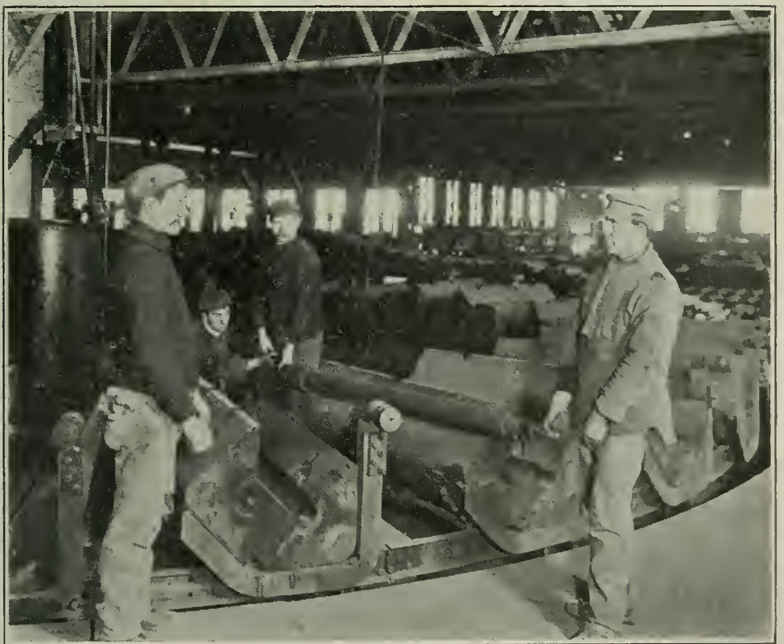
of the resultant gases was thought would prove to be a great one. Again, the pipes were less than one-fourth inch thick and it was necessary to pour the iron very quickly. So far as was known, no one had successfully poured a complete pipe in an iron mold, and such attempts that had been made had destroyed the mold very quickly. A mold six feet long would be permanently warped in a short time, hence it is not surprising that the experiments were approached with considerable trepidation. The first mold made consisted of a cope and drag, each six feet long, ten inches wide and six inches thick, with gates cut into the drag, as shown in Fig. 1. This mold was cast of very soft iron and the pipe shape bored out. The pouring holes "A" were tapered so that when the cope was removed the iron in them could be easily knocked out. In order to avoid as far as possible all traces of moisture the mold was heated to 500° F., an ordinary green sand core was inserted and four men poured molten iron into the gates. These men wore goggles and were swathed completely in wet cloths. We did not then know what would happen. As it turned out nothing happened—not even a semblance of pipe—the gates were too small. A short session with a hammer and chisel made them larger, and on the second attempt a complete pipe was poured. It was not a remarkable pipe except for its defects. It was streaked with cold shot, the top was filled with flat spots where the gases had been trapped, and it was as hard as flint. After an infinite number of experiments the mold now in use was evolved. A complete description of this mold as it appears on the machine will be given later. After fifty or sixty pipes had been cast in this mold, it became badly cracked around the gates, and as the process of casting was continued these cracks extended into the barrel of the mold. This we attempted to obviate by casting into a new mold very thin strips of mica, extending throughout the length of the mold and placed radially at intervals around the barrel or mold cavity. The cracks we found in this mold would start as before but would stop when the mica was reached. A good illustration of this effect is shown by the fact that a small hole drilled at the extremity of a crack in a sheet of plate glass immediately stops the further extension of the fracture. In time the whole face of the mold would show a collection of fine cracks, most of which

Finished core.



Pouring.

Original pouring device, ladle in lower position.



Passing core to core setters.

could only be seen with a magnifying glass. They rarely ever were more than 1/16 inch deep. After probably 200 pipes had been cast the surface of the mold in contact with the molten iron resembled an extremely hard graphite. It was dull black in color but did not scale or shell off. In order to thoroughly test the mold, the ends were stopped up with sand and the entire barrel, without a core, was filled with molten iron. This was done thirty or forty times without any appreciable deterioration of the outline. The only care exercised was to take the casting out before heavy shrinkage set it. In order to still further test it, the mold was heated to a temperature of about 1100° F. in a furnace, but it was found impossible to produce pipe under these conditions. The molten iron danced in the mold like water on a hot griddle and the resultant pipe was a collection of closely-knit globules. It was found that the safe casting heat of the mold was about 700° F., but that in a practical working 250° F. to 400° F. was the highest heat the molds reached. The actual time in which metal set was carefully noted and the behavior of the cast metal at extremely high temperatures was observed. Irons high and low in silicon, sulphur, carbon or phosphorus were cast a great many times and copious notes were taken in each case. A small chemical laboratory was established for this work. In all over 4600 pipes were cast in 4″ pipe mold, 2700 in a 2″ mold and over 1100 in a 6″ mold. Not one of these molds shows any signs of deterioration over and above the first cracking as described before; in fact, they are in a far better condition than at the start. Each one has been purposely abused and submitted to treatment that never occurs in practice. A straight edge today laid in the barrel shows the surface to be perfectly straight and the 4600 pipe shows the original marks of the boring-out tool.

It was found that an iron running from 2.00 to 2.25 silicon and high in carbon produced the greatest number of perfect pipes, and when cast-iron of this silicon had a comparatively low sulphur content, the result was still better. Further experiments showed that powdered ferro-manganese when added to the molten iron, immediately combined with the sulphur as a manganese sulphide, and rose to the top of the liquid mass as a slag. An excess of manganese, however, produced a hardening effect

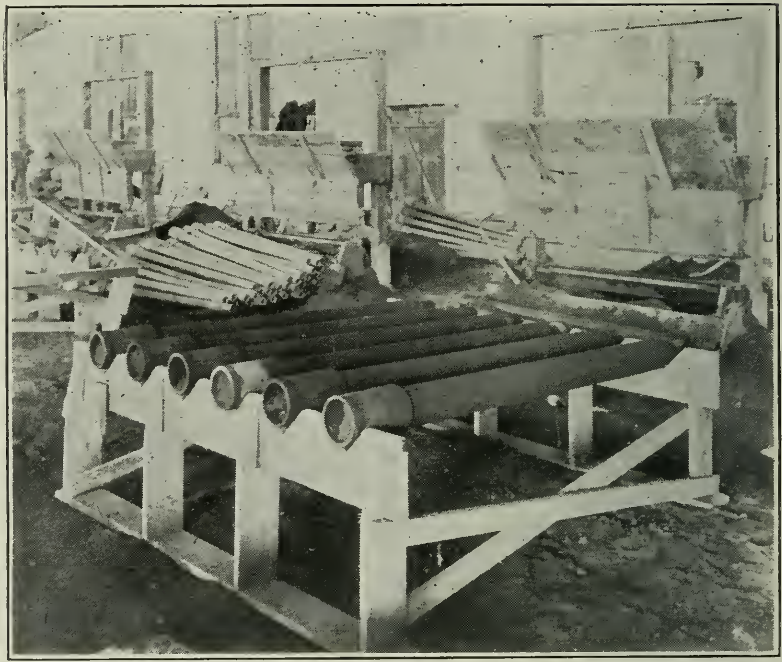
as it formed with the carbon, a carbide which in itself is an extremely hard substance.

These features made it possible to use a high sulphur cast-iron, providing its other contents approximated the figures given above.

It was then noted that pipes that remained in the mold until a dull red heat was reached were very hard, and in most cases were too hard to cut. When they were taken out at a bright yellow heat and allowed to cool normally they were perfect in texture. It was further noticed that when the dull red pipes were piled with the very hot bright yellow pipes, an annealing process was set up that brought the iron in the dull red pipes into a workable condition. This feature of temperature was the subject of a long and patient investigation and the causes leading thereto may be now briefly stated.

Pure iron possesses no fluidity, or the property of low shrinkage, nor does it possess varying degrees of hardness. It is obvious then that the characteristics of cast-iron, which possesses these qualities in a high degree, are due to the presence of impurities, such as carbon, silicon, phosphorus, etc. Carbon is the main element and exists in cast-iron as combined and free carbon. The amount of free carbon, which is the principal softener of cast-iron, depends principally upon the rate of cooling. If molten iron high in carbon be cooled slowly the free carbon separates out in the form of graphitic carbon. If this molten iron be suddenly cooled, the carbon is caught before it has time to separate and is held in an atomic condition by the enormous pressure of the surrounding iron. Therefore, the fracture of a pig of iron is generally an index of the rate at which it is cooled. If the suddenly cooled iron be re-melted and slowly cooled, it will assume all the characteristics of soft iron. The graphitic carbon will become plainly separated and large crystals will be formed. It may be stated that cast-iron in a molten state is a solution of carbon and iron and the mass is homogeneous.

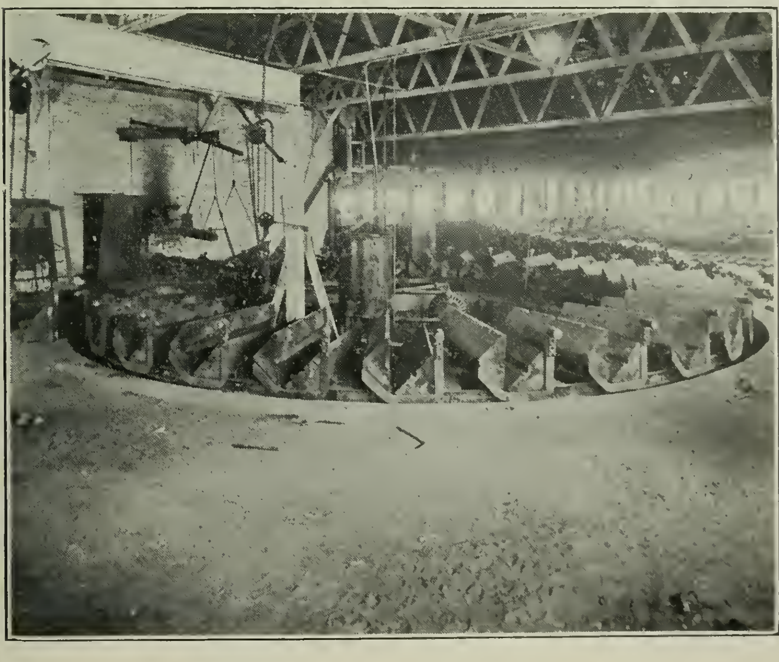
Silicon in itself confers no benefit on cast-iron. It is only its influence on the carbon contents that produces beneficial results. On the other hand an excess of silicon renders cast-iron absolutely unfit for use, making it very hard and brittle. A small quantity through its action on the carbon, reduces shrinkage, in-



Arbors and finished cores, ready for setting.

Original pouring device, ladle in highest position.

Finished pipe before removal of arbor.

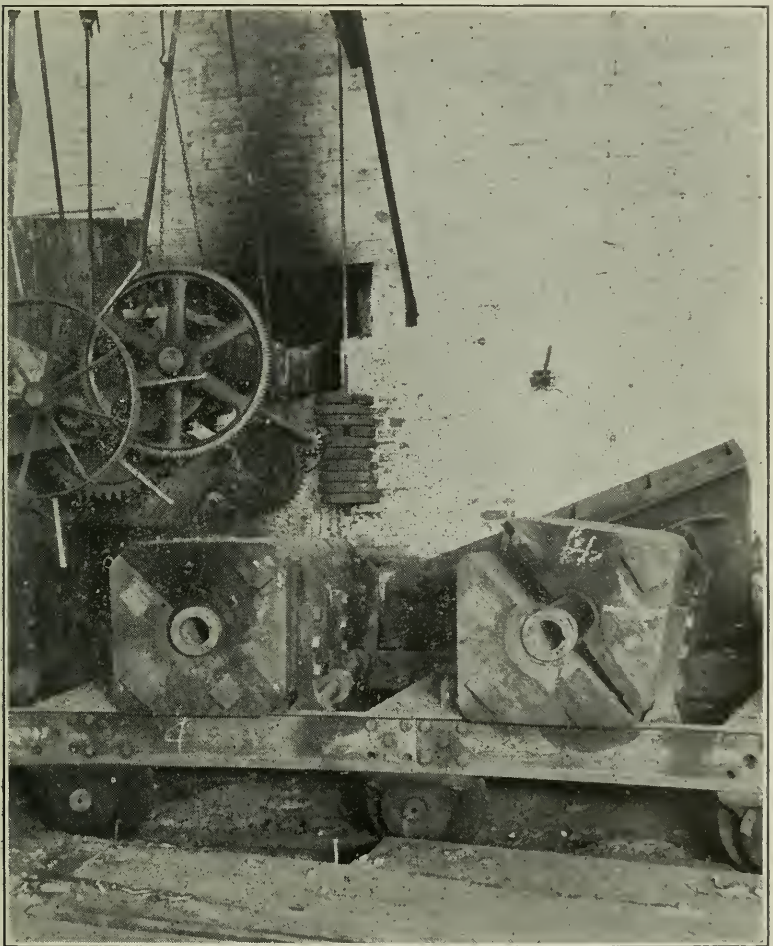


View of machine.

creases strength and increases fluidity. Given then cast-iron comparatively high in carbon with the proper amount of silicon and the ideal conditions are attained. The uses of phosphorus and manganese are too well known to require discussion and play no part in the method except as correctives. Keeping these facts in mind it may be stated that an ordinary foundry iron very nearly fulfils these conditions, with the exception of sulphur. Molten cast-iron is therefore a solution of carbon in iron with the addition of silicon, phosphorus, sulphur and manganese, all forming a homogeneous fluid mass. Now, if this mass be suddenly cooled, it is still homogeneous, the different elements not having time to segregate. If the cooling be continued at the *same rapid rate* until a temperature of about 1600° F. is reached the iron becomes very hard and brittle. But if this sudden cooling is carried out only until the iron is set, and is then removed from the cooling influences, thus allowing the iron to lose its heat normally, the result is a structure whose fracture shows a very fine, close grain. It is tough, since all its particles are thoroughly interlaced, and it is strong because very nearly all the carbon is held in the combined state. In other words, it is homogeneous. Now, let us try to make this vital point plainer.

In a casting, such as a thin pipe, when cast in an ordinary sand mold, it requires about one minute to cool from the temperature of molten iron to the point at which the metal is set. It is in this period that the detrimental effects as shown in cold cast-iron are produced. Phosphorus and sulphur and carbon segregate, and graphitic carbon is formed. Bear in mind that in this period the iron is in a liquid state with all its elements free to move. Once the casting is set all segregation ceases, and the remaining carbon begins its beneficial work. As the iron loses its heat at a normal rate, annealing and carbide carbon are formed, both of which improve the quality of the metal. Now, if we suddenly shoot the molten iron into an iron mold it sets very quickly and the evil period is reduced in time from sixty seconds to two seconds—so short a time, in fact, that all the impurities are held in the position they occupied in the molten mass. The evils of sulphur and phosphorus are reduced to a minimum since they are in practically an atomic condition and are distributed evenly throughout the casting; and since no graphitic carbon is formed all the car-

bon exists as combined carbon, with a corresponding increase in its power for improvement. If the casting is removed from the cooling influence, in this case the iron mold, and allowed to cool normally, the ideal conditions are obtained. Chilling cast-iron to



Immediately after pouring. Mold entering opening device, showing ends of core arbors and mold partially open.

the point of extreme hardness is purely a mechanical process and the point to which the process of sudden cooling can be carried can be determined to an absolute certainty. It is simply a ques-

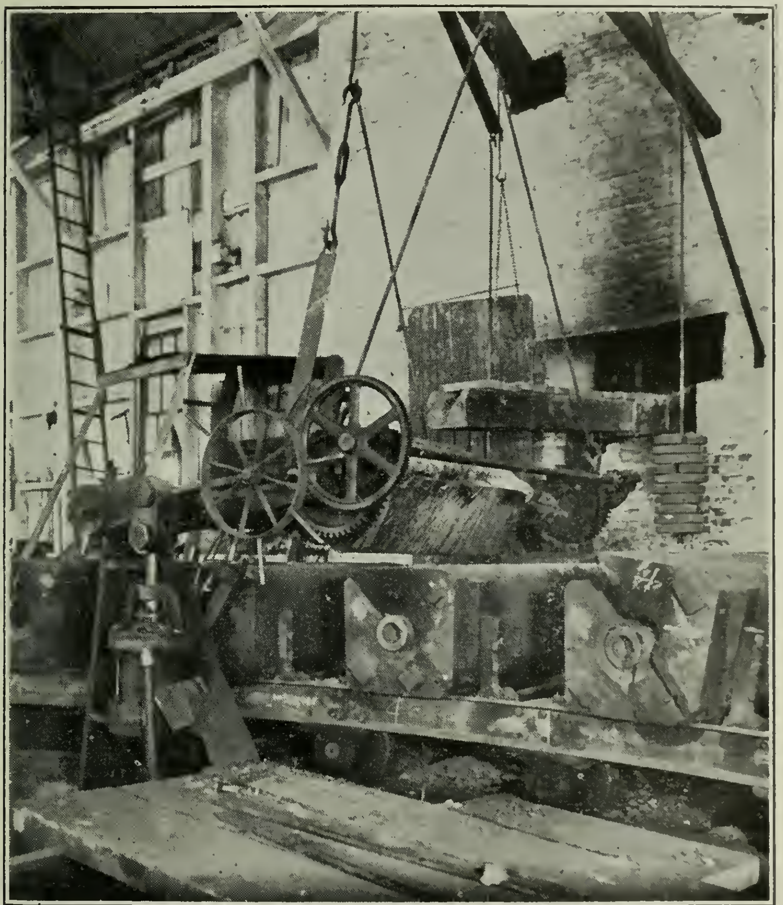
tion of time. The data collected show that a two-inch pipe can be removed two seconds after pouring, and should not remain in the mold more than six seconds. A six-inch pipe can be removed in six seconds after pouring and should not remain more than twelve seconds. This time depends upon the thickness of the pipe walls. Very thin pipe would require not only a shorter time in the mold, but should be cast of iron higher in silicon. The reason for this is that silicon, by its action on the carbon, keeps the iron in a fluid state longer than normal. Every foundryman knows there are irons in which it is impossible to form a chill, and there are other irons in which it is impossible to prevent it. The same limitations apply to making pipe as to the making of other iron products. A suitable iron must be provided if the very best results are to be obtained. This statement applies to any branch of the foundry business and is not set out as a new discovery. What is claimed and demonstrated is, that a poor iron is improved and rendered suitable for the work in hand.

With the data obtained the work of designing a machine that would operate continuously was begun. The experiments had shown that when pipes were cast in a mold every eight minutes, the temperature of the mold never rose above 450° F., even if the operations were continued for hours. If pipes were poured every two minutes the temperature of the mold rose rapidly, and at 900° F. it began to warp. In order to follow the best conditions and avoid the worst, the following apparatus was designed:

The machine consists of an angular table or ring approximately forty feet diameter outside, carrying thirty molds, arranged at equal intervals thereon. The table is constructed of two concentric rings of channel beams, connected with thirty cross pieces or trucks, each of which has two wheels having roller bearing axles. These wheels are arranged to run on concentric circular tracks set in concrete foundations. The tracks are arranged as if on the surface of a cone and by this means is created a tendency of the table to resist any movement other than rotating about its center. Either outer or inner track may be the higher as the effect is the same in either case.

Each truck or cross bar of the table carries a steel pin working loosely in a vertical hole, and of such length as to allow about two inches of pin to project below bottom line of truck, but admitting of being pushed up until flush with bottom of truck.

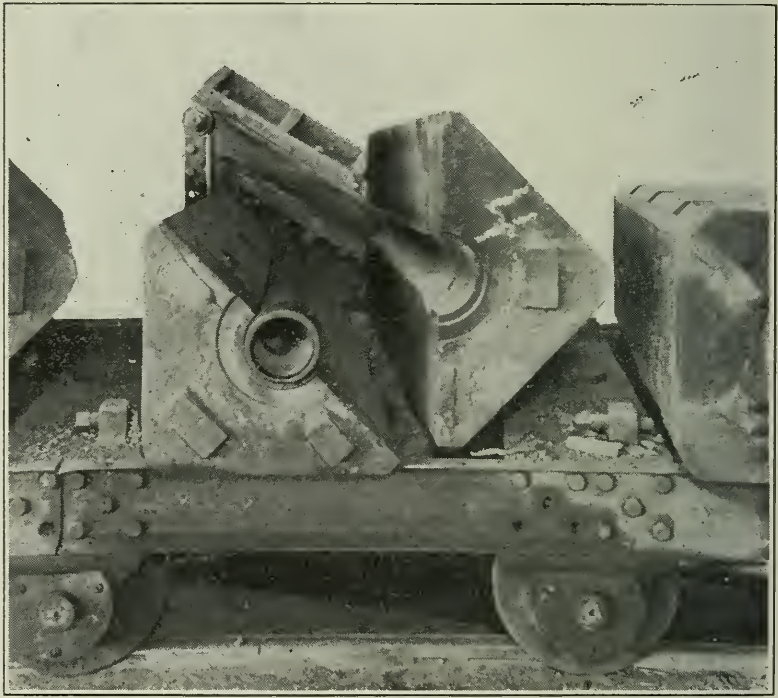
Under the table or ring, at two diametrically opposite points, are arranged two hydraulic cylinders which slide in ways similar to a planing table, the pistons within the cylinders being held stationary and the cylinder moved back and forth by the operation of a four-way valve controlling the admission of water, altern-



End view original pouring device.

ately to each end of the cylinders. The stroke of the cylinders is of such length as to be slightly more than the spacing of molds carried by the table, and projecting from the top of cylinder is an inclined plane surface designed to lift the pins in the trucks, when

the cylinders move in a direction opposite to the required motion of the table, and to allow a pin on each side to fall, after the inclined surface has passed. This occurs at or near the end of the backward stroke of the cylinders, and when the controlling valve is so moved as to cause the cylinders to move forward, the pins which have been lifted and allowed to fall are brought in contact with the projections on the cylinders and hence the table is car-



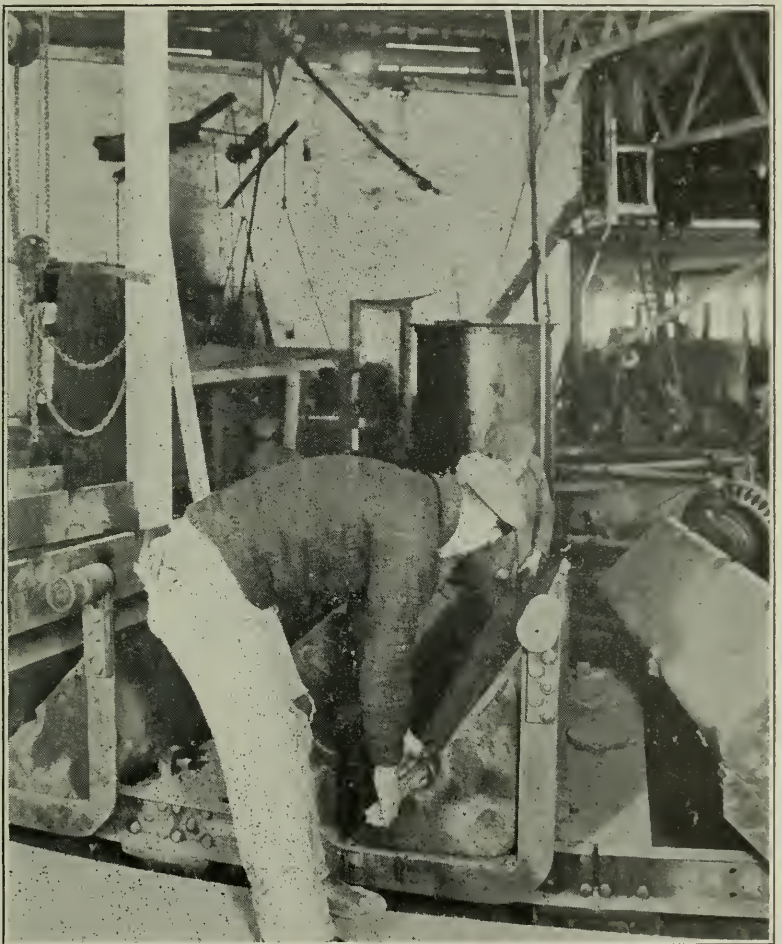
Mold entering closing device. Core in place.

ried forward by the motion of the cylinders, a distance equal to the spacing of the molds, and the cylinders are ready for another return or back stroke to engage the next pins, thus intermittently moving the table ahead one space at each cycle of the cylinders.

The center of the table is left open for the location of hydraulic pumps, operating valve reservoirs, etc., required in imparting motion to the table. This table makes one complete revolution every seven and one-half minutes and consequently produces

thirty (30) pipes in that time, or two hundred and forty pipes an hour.

At certain points about the table are arranged closing and opening devices, which are designed to close the mold, or bring the



Setting core.

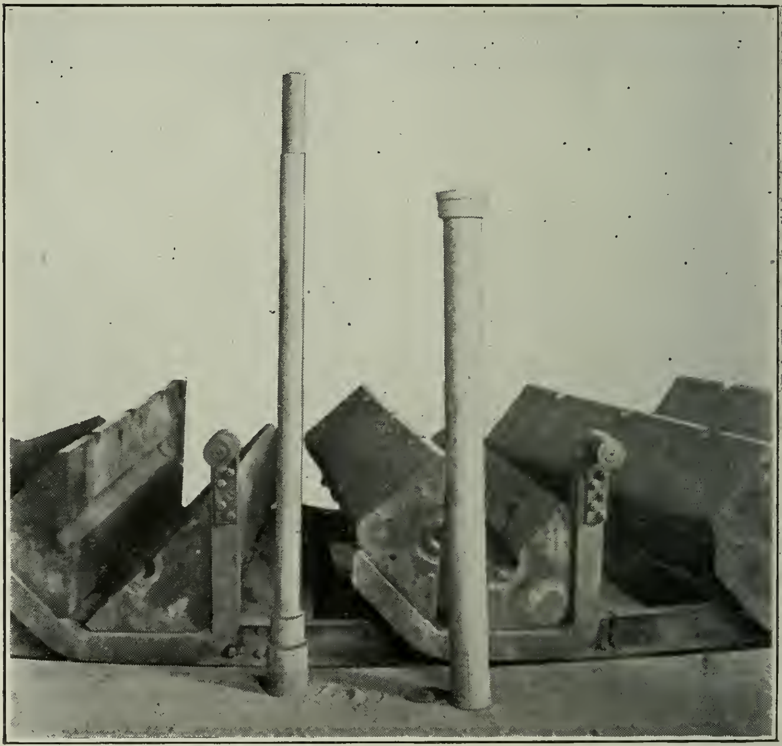
cope side down to its place on the drag side, without shock, after the cores are set in place, and to open the mold or lift the cope after the pipe has been poured.

Between the closing device and the opening device is located

a pouring device adopted to receive the molten metal from the cupola and pour it into the molds.

DESCRIPTION OF MOLD.

Each mold consists of a rectangular block of cast iron, approximately eighteen inches wide and eighteen inches high, by six feet long. parted on a diagonal line across the corners. and pro-



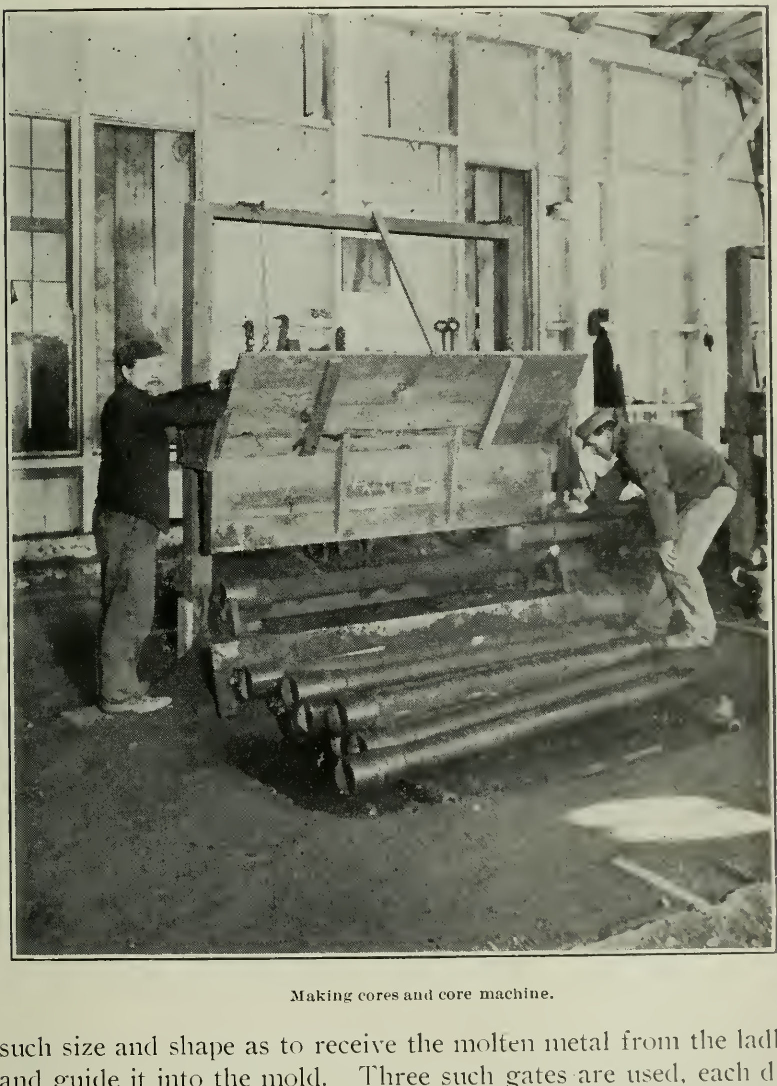
Finished pipe and core arbor. Molds open.

vided with hinges at the lower edge of the parting so as to allow the upper portion or cope to be swung up and back from the lower portion or drag. These molds weigh about 6500 pounds complete.

At the center of the mold is the cavity into which the metal is to be poured to form the pipe. Thus one-half of the pipe is

formed in the upper and one-half in the lower portion of the mold.

Gates are cut in the face portion of the lower part or drag of

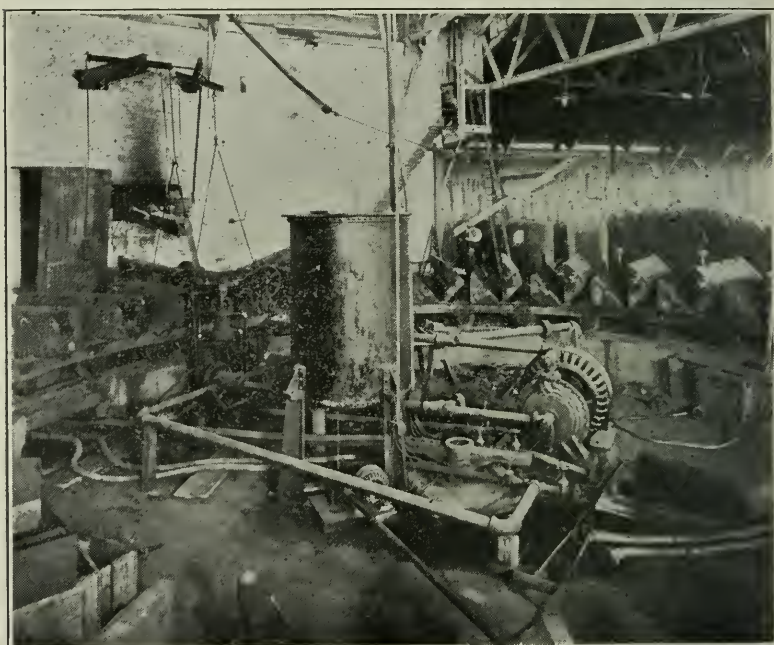


Making cores and core machine.

such size and shape as to receive the molten metal from the ladle and guide it into the mold. Three such gates are used, each dividing into two portions and so entering the cavity of the mold at six points.

(a) These gates are so shaped as to receive the shock of the falling stream of molten metal at a point outside of the mold cavity, and convey it into the mold quickly but gently so that the core is not damaged by a rush of molten metal against it.

(b) At the highest point of the barrel of the mold a small groove is cut, extending throughout the entire length of the barrel. This groove, which is quite small, being only one-eighth of an inch wide and deep, is intended to receive any gases or air

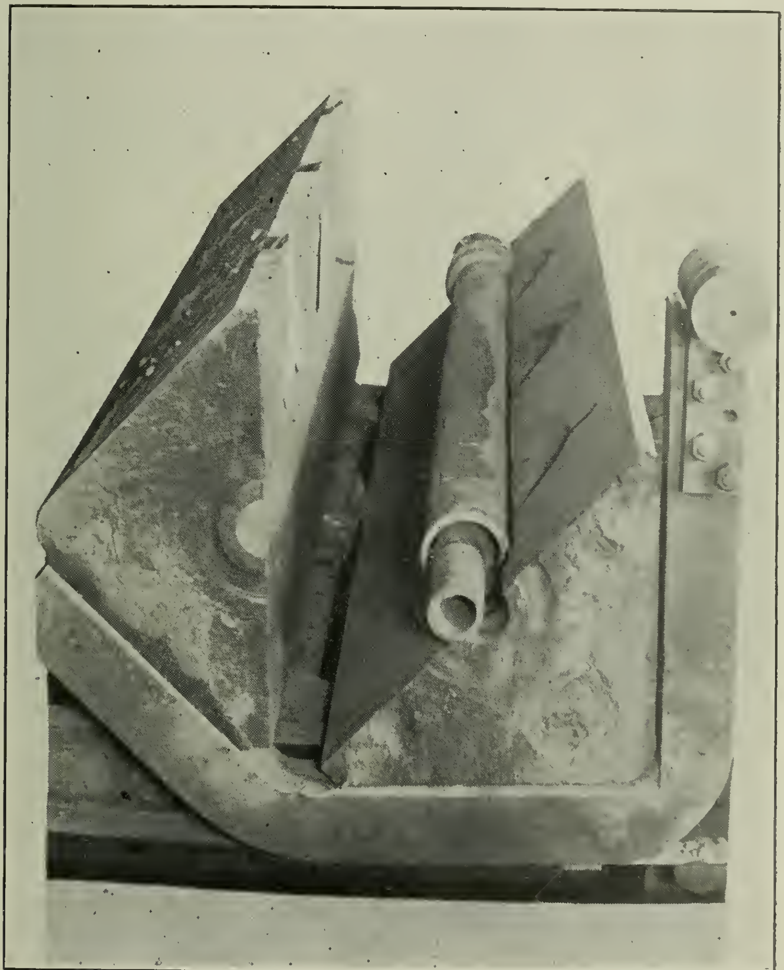


Motors, pumps, valves, piping and reservoir.

which may be trapped in the mold, and so avoid the formation of flat spots at the top of the pipe. The resultant ridge not being prominent is not an objection but rather adds to the strength of the structure.

On one end of each mold is carried an arm rigidly attached to the upper or movable half. This arm extends under the mold and is of such form that when the mold is open it forms a rest for the movable half, holding it in such position as to allow of any work, such as setting cores, removing finished pipes, cleaning,

etc. On the end of this arm is a steel roller which is caused to travel down an inclined plane by the rotation of the table carrying the mold. This inclined plane is arranged to receive the roller at its higher position when the mold is open, and to guide it



Open mold, showing finished pipe.

smoothly to its lower position, by this means closing the mold without shock or jar to disturb the core. This inclined plane constitutes the closing device.

Each end of the mold is provided with rings or bushings which are used to support the core arbor in a precisely central position in the cavity of the mold, so that the pipe when finished shall have uniform thickness of metal at every point.

The core arbor consists of a cast-iron hollow cylinder somewhat longer than the pipe to be cast and about three-quarters of an inch less in diameter than the inside diameter of the pipe. It is perforated throughout most of its length by small holes to allow any gases formed by contact with the molten metal to pass into the arbor and so have free vent to the air through the ends of the same.

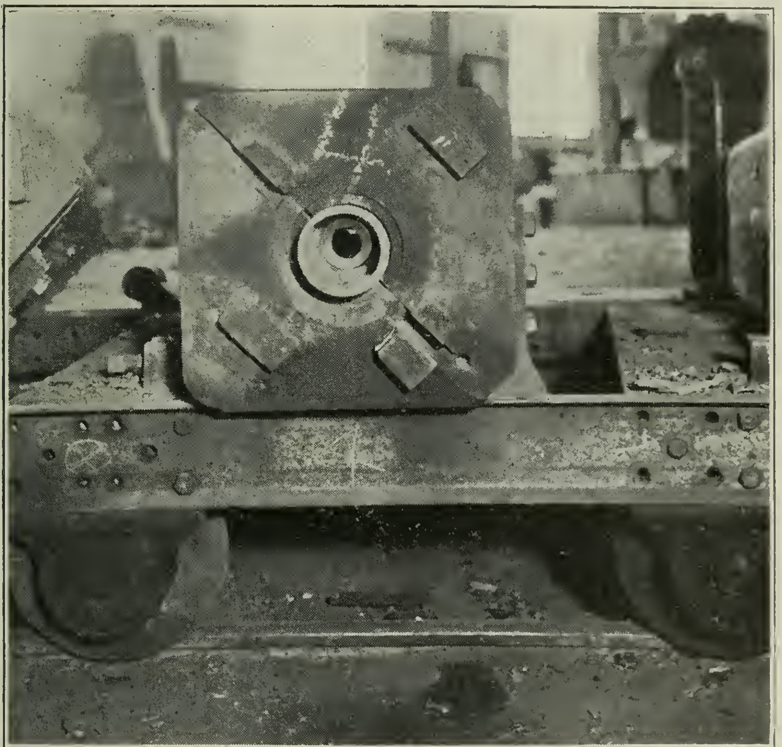
Each end of the arbor is accurately machined to fit the rings or bushings in the ends of the molds.

The core is made by placing the core arbor in the core machine, which consists of a support for the ends of the arbor, semicircular in form, and of a diameter to fit the arbor ends; a shaking screen arranged to sift sand, and a guide to drop it upon the arbor, and a knife, so shaped as to form the sand to the outline of the inside of the pipe.

The core arbor after being wet thoroughly is placed in the end supports and rotated by a crank-shaped piece of iron held loosely in one end, by an operator. At the same time another operator shakes a sieve suspended over the arbor and previously filled with sand, tempered to the proper degree with water. This sieved sand is caused to fall directly upon the wet, rotating arbor and clings to it. The surplus sand is scraped away by a steel knife held at the proper distance from the arbor to make the finished core of the diameter and shape required. When sufficient sand is on the arbor to make a full and complete core (which requires about five seconds) the core is lifted from its supports and is ready for use. No further treatment of any kind is needed, and the core is placed in position in the mold, which is then caused to pass the closing device, bringing the upper portion down in place and the mold is ready to receive the metal.

A ladle is provided to receive the metal as it flows from the cupola. This ladle is arranged so that it can take a position high enough to allow the molds to pass freely under it, or it can be lowered into a position between two adjacent molds, so that the pouring spouts or lips of the ladle are very close to the pouring holes of the mold.

As the table rotates and brings a mold, which has passed the closing device, into pouring position the ladle automatically drops into this latter position with the lips close to the pouring holes. The ladle is then tilted to pour by the operator, but in tilting it rotates around a center line which passes through the pouring lips, and hence the points of pouring do not move; and the streams of metal are guided directly into the pouring holes through the va-



Closed mold. Core arbor in place.

rious gates into the mold and fill it completely, compressing any air or gas which may be trapped into the groove provided at the highest point for that purpose. If no gases are trapped, which, strange as it may seem, is usually the case, this groove is also filled with metal and forms a slight rib running the length of the pipe.

When the pouring operation is complete and operator tilts the

ladle back, it automatically rises to its higher position so that the next mold may pass under it and assume the pouring position.

The mold being now filled with metal, is held long enough to allow the metal to set and then opened by passing the opening device, which is just the reverse of the closing device; the roller on the end of arm or mold, being guided up an inclined plane, thereby lifting the upper half or cope side, and swinging it away from the lower or drag side.

The pipe, which is still a bright orange color, is lifted from the mold and placed, after removal of gates, with those previously cast, in piles, to cool slowly, when the core arbor is withdrawn and returned to core machines to be used again.

After removal of the finished pipe from the mold, the loose sand which falls from the core during the handling of the pipe, and any other dirt, loose gates, etc., which may be left in the mold are swept out by air blasts or hand brushes and the mold is ready for another core and another filling with metal.

The method of pouring is very important; in fact, the success of the whole operation hinges very closely upon properly carrying out this scheme. By it is secured equal velocity and pressure of the molten metal as well as simultaneous action. Too much stress cannot be laid upon this feature. The difference between a good pipe and a bad one is the difference between good and bad pouring.

Section of Physics and Chemistry.

(Stated meeting held Thursday, April 9, 1908.)

Methods for Protecting Iron and Steel Against Corrosion.

(A Review.)

By Geo. B. Heckel.

Gentlemen:—This paper should be prefaced by an explanation. The Executive Committee of the Franklin Institute, in their inscrutable wisdom, imposed upon me the duty of addressing you upon a subject regarding which doubtless many of you are better informed than I. I presume that I owe this distinction to my official position as Secretary of the Paint Manufacturers' Association of the United States, and my connection with Committee "E" of the American Society for Testing Materials. I do not, however, pose as an expert or authority on this or any other subject, and therefore I took the liberty of changing the title of the address as originally proposed to me, and shall speak rather in review of the work of others on protective coatings than of my own knowledge of the subject.

Steel has, within a few years, come into almost universal use as a structural material, and with the introduction of reinforced concrete its application promises still greater expansion. Steel, and especially Bessemer steel, is subject to corrosion from atmospheric agencies, and upon our ability to protect it from corrosive attacks depends the permanency of our bridges, our sky-scrapers, the beams and girders of our factories, etc.

Dismissing for the moment all forms of corrosion excepting that form of oxidation popularly known as rusting, it is essential as a starting point to inquire, what is rust and what causes it?

When a steel plate is exposed to an atmosphere charged with

moisture it may or may not rust. The difference is easily observable in ordinary conditions. On some days when the atmospheric moisture is high all exposed steel will quickly show rust stains. On other days when the degree of moisture is equally high, rust will form but slowly, if at all.

There must be a cause for these differences of behavior under apparently identical conditions.

From the facts which follow it would appear to be due to the presence in solution of larger or smaller percentages of carbonic acid, mineral acids from smoke and of ozone. For, as will be shown later, some agencies distinctly promote, while others retard, or completely inhibit oxidation.

Ordinary iron rust is perfectly familiar to everyone. It is a yellowish, reddish or brownish substance and normally consists essentially of hydrated ferrous oxide, though as shown by Dr. Toch, the degree of oxidation and hydration may vary considerably in the same samples of rust, the exterior portions of the layer generally tending more towards a stable oxide and the portions next to the metal being highly ferrous in composition.

I do not intend to review the chemical constitution of rust nor to trace the chemical processes involved. All forms of rust depend for their formation on the fact that oxygen in solution in water enters readily into combination with iron and that carbon dioxide and other acids in the atmosphere may act as promoters and modifiers of the process. The entire subject is discussed at length in the writings of Wood, Toch, Dunstan, Jowatt, Moody, Walker, Cushman, and others, and is summarized in the United States Department of Agriculture, Office of Public Roads, Bulletin No. 30, to which the curious are referred.

Formerly it was supposed that iron immersed in pure water *in vacuo* would not rust; but Whitney and Cushman have conclusively shown that iron does pass into solution in pure water without the presence of free oxygen or other agent, and this fact opens the way to an entirely new method of protection, which we shall consider at greater length as we proceed.

Hitherto the problem of protection has been regarded as merely a problem of isolation,—the exclusion of moisture and oxygen, and doubtless if we could effectually and permanently exclude the agents of rust we could preserve our material indefinitely.

Two methods of isolation are generally employed, either sepa-

rately or simultaneously. The interposition of a film of paint between the surface of steel and the atmosphere or the deposition of a firmly adherent film of non-corroding metal in the same position, as in the coating of roofing sheets with tin and lead and the deposition of a film of zinc in the so-called "galvanizing" processes.

Regarding the latter, which may be very briefly considered, it is worthy of note that the new process for coating a surface of steel with a film of zinc by subjecting the steel plate to a low heat in contact with zinc dust, seems, from the meagre reports at hand, to give promise of excellent results in the future. In this process, it is said, the zinc penetrates the steel to an appreciable extent and forms a continuous film of metal over its surface. If this process shall be made commercially available there is no apparent reason why steel so coated shall require further preliminary protection, the deficiency of ordinary galvanized iron being apparently due to the imperfect continuity of the zinc coating.

A steel surface properly covered with a coating of metallic zinc, and insulated from contact with other metals, should need no further protective coating for a long period. Mr. Stone, of the New Jersey Zinc Company, tells me of galvanized roofing plates that remained in service for sixteen years and then were put out of service only because the building was demolished.

But manufacturers have learned how to economize zinc since those days, and the zinc coating no longer fully protects because it is too thin and is not continuous.

Let any one compare a piece of coated telegraph wire with a piece of ordinary galvanized plate by subjecting them for a time to the action of moisture under identical conditions and he will at once recognize the difference between complete and incomplete coating. It would also be interesting to compare with these a specimen of the Sherardized steel before referred to.

Still another method of coating steel with metallic zinc is the electrolytic process, of which I have samples here. Advantages of economy as well as of purity and homogeneity of coating are claimed for this electrolytical or cold process galvanizing. The claim of superiority at least would seem to be justified by the results with these small samples, which have been immersed in water for over three months without showing signs of rust. One specimen had its uncoated end protected with paraffine wax, the

other was not so protected. The process is said to be applicable to any size or form of steel. (Show specimens.)

What I wish here to emphasize is the fact that a properly galvanized metal surface needs for long periods no additional protection. Paint may be applied for decorative purposes, but is unnecessary at the beginning for any other use.

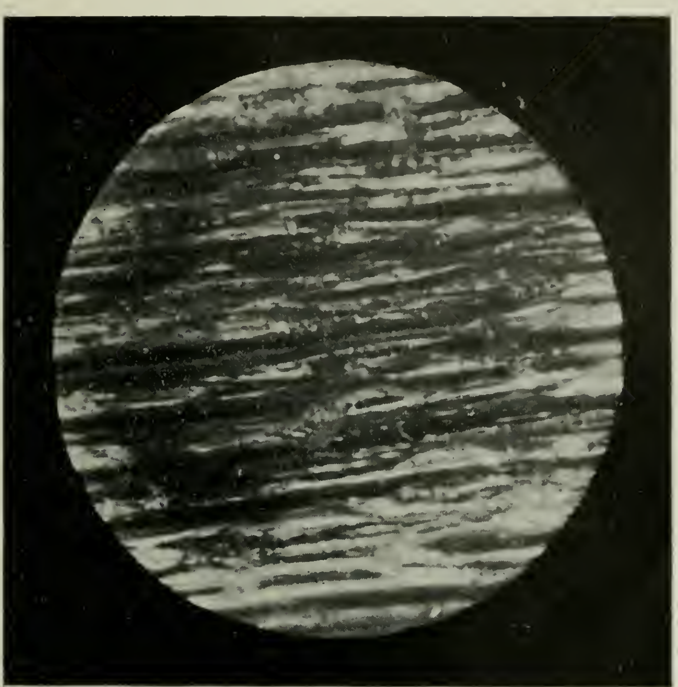
While we are upon the subject it might be worth while to note in passing, the proposition made some years since by certain engineers that masses of zinc in electrical contact with the steel be buried in the foundations of our sky-scrapers. The idea, of course, was that the zinc being the electro-negative member would be corroded, while the steel would be preserved.

For the benefit of our mining and smelting interests we might wish to see this method generally adopted, with provision for the renewal of the zinc as corrosion proceeded.

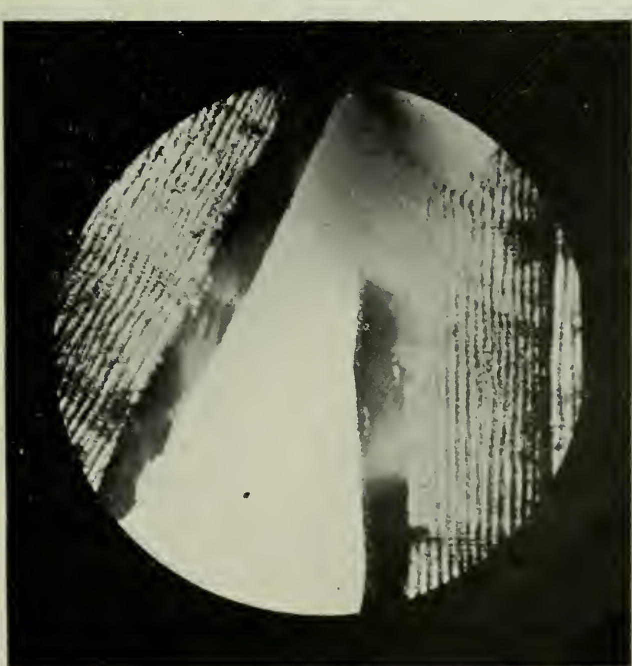
The problem of protection by painting metallic surfaces comprises several important factors, differing materially from the conditions presented by a surface of wood. In the latter we have a more or less absorbent or porous surface, every minute aperture of which affords a hold for the film of paint. Furthermore the coefficient of expansion for any wood under change of temperature is so low as to be negligible. If we can exclude moisture from the painted wood, the protective coating is subject to practically no stresses or strains.

Steel, on the other hand, presents to the eye an intact surface. It is only under magnification that we detect its actual irregularity. Two forces probably tend to hold a film of paint in place on such a surface: First, the hold of microscopic projections from the under surface of the film on the irregularities of the metal surface, and second, the force of cohesion or atmospheric pressure. The coefficient of expansion for steel, within the limits of range for atmospheric temperature, is high—far higher than that of any known paint film. This deficiency in the latter must be compensated for by elasticity. The film must be sufficiently elastic to accommodate itself to the constantly changing area of the surface to which it clings, without rupturing the film itself or the minute projections by means of which it clings to the surface.

Finally, since moisture, acid, ozone and perhaps other atmospheric agencies are at least the principal causes of rust, the pro-



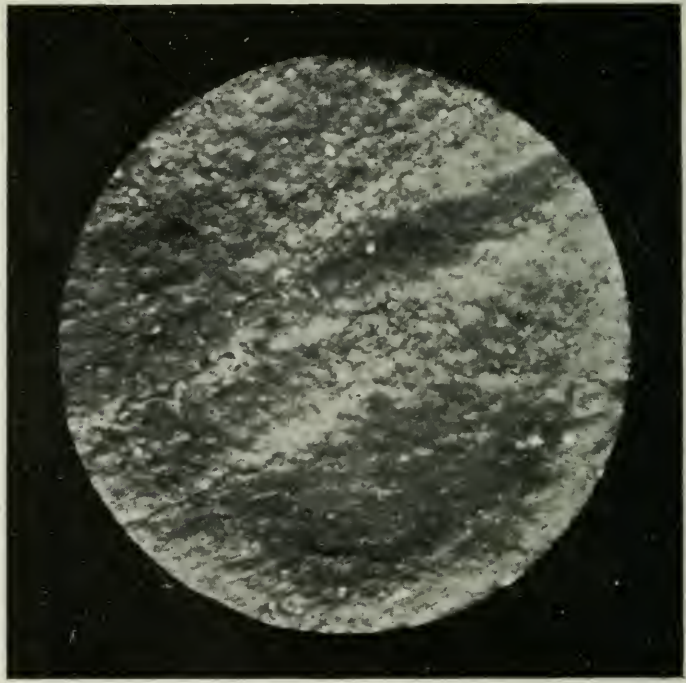
Micro-photograph of wood surface.



Micro-photograph of paint films on wood.

tective coating must, insofar as possible, be impermeable by vapors and gases.

From the stated difference of the two surfaces it is readily deduced that a paint to penetrate and secure a firm hold on the microscopic irregularities of a steel surface must be different from a paint intended to penetrate and adhere to wood, while the rigidity of the one as contrasted with the softness of the other would indicate other differences.



Micro-photograph of steel surface.

For example, Mr. R. S. Perry has propounded a very interesting theory in which a parallel is drawn between the paint film and concrete, and from this he deduces the desirability of three determining sizes in the pigment particles to fill voids. But bearing in mind the extremely minute size of the projections and apertures, it would seem reasonable to assume that in the undercoating at least of a protective paint for such a surface the pigment particles should be extremely fine; and furthermore, as it is exclusively

the vehicle and never the pigment that imparts elasticity to the coating, that the elastic vehicle should be in excess.

The Scientific Section of the Bureau of Promotion and Development, Paint Manufacturers' Association, under the direction of Mr. R. S. Perry, is doing very much valuable work in the way of furnishing technical data, and among other information it has furnished measurements of the particles of several pigments in common use. Following are the measurements given me:

White Lead (Hydrocarbonate)	.000074	.033
White Lead (Sublimed Lead)	.00003	very uniform
Zinc Lead	.00004	" "
Zinc Oxide	.00002	" "
Carbon Black	.007	.0007
Lamp Black	.00009	
Mineral Brown	.06	.007
Red Lead	.006	.08
Silica	.00024	.0016
Calcium Carbonate	.00012	.0016
Barytes	.00008	.0004
Gypsum (Thin Plates)	.00032	.0019
Asbestine (Long Rods)	.00016	.0032
China Clay (Thin Plates)	.000016	.0028

These measurements represent the dry pigments as they come upon the market. With some of them chemical changes effected in combinations with oil acids profoundly modify these mechanical factors; with others, keeping in mind the conditions to be met, extremely fine grinding in the process of manufacturing into paint would seem to be indicated as essential.

Mr. Job, in a paper read before this body some two years since, admirably illustrated from practical experience the necessity of a high degree of comminution in protective paints for metal surfaces. The differences in the behavior of the paints contrasted by Mr. Job would seem to depend first upon the excess of vehicle (the elastic element) in paints compounded with finely ground pigments, and secondly in the smaller area of the voids between the particles of pigment in the paint film. For, as Dr. Dudley has so often and so admirably demonstrated, linseed oil is to a surprising extent permeable by moisture, and it is the province of the pigment, to a large extent, to compensate for this quality of linseed oil, by presenting a series of impenetrable layers of pigment to the atmospheric vapors.

In the early days of English and Scotch steel ship building it was the custom—which still prevails to some extent—to give all steel members, while hot, a shop-bath of linseed oil. Something like this had evidently been done with the steel used in the Havre-de-Grace bridge, on which Committee "E" is now experimenting. In that case it did not prevent rusting, but entailed much labor to remove it. The coating was not protective and had become so brittle that it would have formed a very unsafe foundation coat.

In the practice of some firms it is the custom to give all structural steel a shop-coat of red lead and linseed oil. This practice is far less objectionable, as red lead does at least make a good foundation for subsequent painting. As to the relative merits of red lead and other pigments, the subject is too wide for me to handle. Perhaps if red lead were always mixed fresh on the ground and applied while freshly mixed, there would be much less room for controversy.

We now come, in the course of our review, to one of the most interesting developments of modern paint chemistry—a development which may eventually solve our problem, leaving nothing for future workers, or which may prove a mere *ignus fatuus* of science, like so many apparent discoveries which have preceded it.

During the year 1905, Dr. Allerton S. Cushman, of the Department of Agriculture, in the course of certain investigations connected with the corrosion of fence wire and steel culverts, made a special study of the curious fact that the corrosion of steel is inhibited for a time by treatment with chromic acid or a soluble chromate. Other investigators had from time to time referred to this peculiar condition of passivity, but so far as I know, Dr. Cushman was the first to investigate its causes and to supply a satisfactory explanation. His explanation briefly depends upon the modern theory of solutions. The familiar phenomenon of rusting is due to electrolysis. The free hydrogen ions in water exchange places with the iron, transferring their electrical charges and changing to the atomic condition. The iron passes into solution and is attacked by the oxygen of the water, further hydrogen being ionized in the process for further attack, and so on indefinitely.

The complete theory is beautifully demonstrated and illustrated in Bulletin No. 30, issued from the Office of Public Roads of the Department of Agriculture, and every one interested in the

preservation of metals should read this bulletin, because it is full of noteworthy information and suggestion. It is only fair to say that Dr. Cushman's deductions have been attacked and that his theories have not met with complete acceptance. Nevertheless he has certainly demonstrated some important facts, whatever may be the ultimate fate of his explanations.

He has, for instance, positively shown that chromic acid and its compounds will inhibit the corrosive action of moisture on iron. He has shown that iron passes into solution in pure water, and he has shown more recently that the mere presence of certain chromates together with steel in water inhibits oxidation.

The results obtained by Dr. Cushman in the latter field are summarized in a letter to me under date of March 11th, as follows:

"I have been conducting a long series of experiments studying the action of various pigments together with water and oxygen on steel. I find that, under the conditions of my experiments, the ordinary commercial mixed pigments fall naturally into three classes:

"(1) Those which prohibit or largely inhibit corrosion.

"(2) Those which have no action one way or the other, and from this point of view are therefore inert.

"(3) Those which stimulate corrosion.

"I am not yet ready to give out the details of the experiments, but I will be very glad to give you one or two points which I should be pleased if you would bring out. My observation that chromic acid and certain of its compounds act as inhibitives has led to a great many experiments by other workers along the same line. Now, I have found that the chrome compounds which are on the market vary very much in their action. Some of them show up as strong inhibitors, while others go to the opposite extreme and actually stimulate corrosion. Referring only to the labelled names of the pigments which I have tried, I find among the good ones, and in the order cited: Zinc chromate, American Vermilion, chrome yellow orange, chrome yellow dd. Among the bad ones, and also in the order given, I find: Chrome yellow medium, chrome green, chrome red. And very much the worst of all is chrome yellow lemon.

"I presume that the difference is due to impurities that are present in the bad pigments. For instance, I believe that the lemon chrome yellow contains some salt or compound which had been

added in order to keep the reaction acid during the process of manufacture so that the bright yellow shade will be preserved. You will understand, of course, that when I speak of 'good' and 'bad' pigments I mean merely in their relation to inhibiting or stimulating corrosion in the presence of water, and this characterization has nothing whatsoever to do with physical state or properties when mixed with oil. It is, however, important in my opinion that these differences should be noted in advance, for if an experimenter should happen upon lemon chrome yellow and obtain bad results with it he might unthinkingly conclude that the whole principle of the chrome protection was at fault."

In explanation of Dr. Cushman's results with the lemon chrome it should be said that this shade is commonly produced by the presence of lead citrate or other similar lead salts and that it is not a pure lead chromate.

Dr. Cushman's remarks regarding the starting of independent investigators is undoubtedly true, and since the publication of his address to the American Society for Testing Materials last June nearly every technical chemist in the country has had a bottle of steel turnings in chromate solution standing convenient for observation.

It occurred to me, for instance, that in estimating the effect of the various atmospheric agencies in corrosion it would be instructive to run a series of duplicate tests in which the effects of the various atmospheric influences should be segregated.

Accordingly I requested Mr. Gardner, of the Scientific Section of the Paint Manufacturers' Association, to ascertain for me with small steel plates cut for me from the middle of the same bar—

1. Whether a steel plate immersed in distilled water in vacuum will show rust;

2. Whether a similar plate immersed in distilled water charged with pure oxygen only, will develop rust;

3. Whether a similar plate immersed in distilled water charged only with ozone will develop rust;

4. Whether a similar plate immersed in distilled water charged only with atmospheric air free from all substances excepting oxygen and nitrogen will develop rust;

5. Whether a similar plate immersed in distilled water saturated only with atmospheric air containing a small percentage of ammonia gas will develop rust;

6. Whether a similar plate immersed in distilled water containing only atmospheric air with a small percentage of carbonic acid and nothing else will develop rust;

7. Whether a similar plate immersed in distilled water containing only atmospheric air with small percentages of ammonia and carbonic acid will develop rust:

8. Whether in all the foregoing tests a current of electricity passing through the plate will stimulate rusting.

In each case I requested that the ratio of rust development be determined.

These determinations were made for me, the tests lasting for one month. Mr. Gardner in his report details the method of procedure, which was technically correct. The complete report is available for anyone who cares to see it, but I shall content myself with tabulating the results: (*See Appendix.*)

Test No.	Medium.	Loss.	Remarks.
1	Distilled water boiled	0.0482	
1-A	Same with electric current	0.087	
2	Distilled water and oxygen	0.0601	
2-A	Same with electric current	0.1211	
3	Distilled water and ozone	0.0768	
3-A	Same with electric current	0.1155	
4	Pure air oxygen and nitrogen	0.0492	
4-A	Same with electric current	0.0911	
5	Pure air—with ammonia: Oxygen, nitrogen and ammonia	0.0406	Little oxide precipitated. Color dark.
5-A	Same with electric current	0.0758	" " "
6	Pure air—with carbon diox: Oxygen, nitrogen and carbonic acid	0.103	Color of oxide brighter than any of foregoing.
6-A	Same with electric current	0.1941	" " "
7	Pure air with ammonia and carbonic acid	0.0921	" " "
7-A	Same with electric current	0.1876	" " "

It will be seen from this summary that in every case the passage of an electrical current from a sal ammoniac cell, averaging 1½ volts, very materially assisted corrosion. Mr. Gardner also reports that of his own initiative he connected the two ends of a steel plate in distilled water by a copper wire joined outside of the bottle, and that in this case also corrosion was increased. He believes this increase to be due to galvanic action.

It then occurred to me that it would throw further light on the

subject if these experiments were duplicated precisely, with the addition of potassium bichromate to the water in each case. Accordingly Mr. Gardner was requested to clean the original plates and duplicate the tests after adding sufficient bichromate to make a one per cent. solution. After thirty days no rust had appeared in any of the test bottles, even the electric current having failed to start corrosion.

These experiments, I think, prove conclusively that the presence of a soluble chromate will inhibit corrosion, and beautifully support Dr. Cushman's claims.

Some years since, Dr. Dudley in the course of his investigations on steel discovered segregations of manganese which acted as centres of electrolytical corrosion. This discovery gave birth to a whole school of manganese writers—but little further has been discovered along that line.

At the present time, however, Dr. Cushman is investigating this subject also and has secured results entirely confirmatory. In fact at this date there would seem to be no room for doubt that the existence in steel of materials of potentially unequal electrical energies is one of the chief promoters of corrosion. Steel low in manganese, carbon, silicon, etc., does not corrode so readily nor so rapidly as a steel showing higher percentages. It has been shown to be possible by mechanically combining pure iron and pure manganese in a finely divided state to cause electrolysis and the visible liberation of hydrogen by merely dropping the mixture in water.

Other investigators have found great differences in the behavior of different steels in the same conditions. Mr. Wirt Tassin, of the National Museum, has suggested that these differences may be due to differences in the micro-structure of the steels, dependent largely upon the temperature at which they are finished.

With a view to obtaining some light on the question, Dr. Dudley kindly furnished me with some steel borings taken from the same piece of mild boiler plate, the first lot from the plate as received from the maker, the second lot after heating and quenching. Portions of each lot were placed in distilled water and in two per cent. solution of potassium bichromate. They are here for examination. In both cases the borings in distilled water show rust, while in neither case does the bichromate test show any change. This test, so far as it goes, would seem to prove conclusively that the condition of the carbon in the steel has no de-

cided influence upon the inhibitive power of the bichromate. (Specimens shown.)

As I remarked at the outset, I do not profess myself an authority on this subject. In fact, so far as I can learn, the subject is one in which thus far many opinions have been expressed and many theories advanced, but few fundamental technical facts established, excluding purely scientific laboratory researches, such as Walker's and Cushman's.

What has been so far accomplished has been largely the result of empirical observation. This hap-hazard observation has, however, brought forward some significant data which it remains for the trained investigator to classify and from which he may gain an inkling of the basic governing principles.

Sabin, for example, long since demonstrated the fact that a coating of tough varnish applied hot to iron pipes prevents rusting in a marked degree. Toch has pointed out the fact that steel rods imbedded for a long time in concrete showed little corrosion on removal. Several observers have proved that oxide of zinc, lamp-black and some other very finely divided pigments under certain conditions are highly protective. The protective value of red lead freshly mixed before application has long been recognized. Scott, in an address before the Master Painters' Association of Wisconsin, stated that steel shutters painted for the J. I. Case Company with basic lead chromate gave protection twice as long as any other material used, etc., etc.

These and many more familiar instances would seem to indicate that we are at last in a position to lay down tentatively, at least, three conditions as necessary for the protection of steel from corrosion. We will briefly consider these conditions:

First. *Isolation.*—The surface must be shielded as effectively as possible from the access of moisture and atmospheric agencies. This involves the necessity for a paint coating less permeable than linseed oil alone; sufficiently elastic to accommodate itself to the continual expansion and contraction of its support. This coating must furthermore be permanently adherent and must retain its elasticity during a reasonably long time. Fine grinding of the pigments used, the addition of China wood oil, varnish gums, and perhaps even a heavy neutral petroleum oil, used under proper conditions, may help us towards this end.

Second. *Insulation.*—If it be found—and it seems to be well

established—that the passage of an electric current through the members of a steel structure, promotes corrosion, it is evidently a part of our task to reduce as far as possible this element of danger.

Third. *Immunization.*—This is to most investigators a new field with unknown possibilities. If it be found, as indicated in Dr. Cushman's experiments, that the mere presence of certain pigments in the paint film tends to retard corrosion, the converse is also probably true, that the presence of other pigments tends to facilitate it. After the investigators have finished their work of classification and have determined for us, in Dr. Cushman's phrase, which are the "good" and which are the "bad" pigments, it will remain for the paint technologist to apply the knowledge to practice. The pigments given in Dr. Cushman's list are all expensive, but it is probable that if there were any considerable demand for zinc chromate, for example, the price would soon fall to a moderate figure, due to increased production.

I was personally so much impressed with Dr. Cushman's original paper and with Mr. Scott's experimental confirmation following so soon after, that having occasion to supply a formula for a protective paint for use by the New Jersey Zinc Company I suggested the following:

40 lbs. American Vermilion,
10 lbs. Red lead,
5 lbs. Venetian red.

Zinc oxide and lamp-black to produce the required tint or shade. Grind in 1 1/3 gallons of raw linseed oil—increasing the quantity as required for added zinc oxide or lamp-black—and $\frac{1}{8}$ gallon crusher's dryer. For use, thin with raw oil and very little turpentine or benzine.

This is Scott's formula slightly modified. I am inclined to believe that the substitution of zinc chrome for the American Vermilion; of any high-grade finely ground iron oxide for the Venetian red; and of American Vermilion for the red lead, would improve the protective value of the formula, while I also believe that the addition of a very little kauri gum varnish, if zinc oxide is used, would be found advantageous, and that the substitution of a certain proportion of China wood oil for some of the linseed oil would improve the wearing qualities of the paint.

Dr. Cushman in reviewing the formula, points out two dangers

confronting us when we attempt to base an inhibitive formula on commercial products. The first is that all carbon pigments, excepting pure graphite, may contain sulphur compounds easily oxidizable to sulphuric acid when spread out as in a paint film. The second is the probability of variation in the composition of basic lead chromate or American Vermilion. Because of these facts, as he points out, it is necessary, before selecting any particular pigment for its inhibitive quality, to ascertain that it is free from acids or acid forming impurities. As a result of his own experiments he recommends the substitution of Prussian blue for the lamp-black in my formula and lays down as a safe rule in the formulation of inhibitive paints, a careful avoidance of all potential stimulators of the hydrogen ions and consequently of any substance which might develop acid; preference being given to chromate pigments which are to some extent soluble in water and to other pigments which in undergoing change tend to develop an alkaline rather than an acid reaction. Calcium sulphate, for example, in any form (as a constituent of Venetian red, for example), he deems dangerous to use because of the possibility of its developing sulphuric or sulphurous acid. Barium sulphate, on the other hand, he regards as practically safe, because of its well-known chemical stability.

In my own formula the substitution of zinc chrome for the larger proportion of American Vermilion, as suggested, would replace an indefinite by a definite chromium compound.

Barium chromate has also been shown by Dr. Cushman's experiments to be an inhibitor of high power, and I have suggested the possibility of producing a good inhibitive chromate by the simultaneous precipitation of the chromates of zinc and barium. Similarly a very brilliant and opaque chromate can be obtained by the simultaneous precipitation of the chromates of lead and zinc on a zinc oxide base. Furthermore, as Prussian blue has been found to be at least safe, it would seem to be possible to produce an inhibitive chrome green by the simultaneous precipitation of the blue and yellow on a barium sulphate or a silicate base. The entire subject is open to investigators and it is to be hoped that definite knowledge will rapidly accumulate as a result of their work.

As I began I close: I am not an authority on this or any other subject, but if I have been able profitably to direct your attention

to the valuable work which investigators—notably Dr. Cushman, Dr. Gustave W. Thompson, and the Paint Manufacturers' Association—are conducting in this field, I shall be repaid for my time and you for your patience, for which I thank you.

APPENDIX.

REPORT ON TESTS OF STEEL PLATES.

(Made to the Paint Manufacturers of the United States.)

By H. A. Gardner.

Fourteen steel plates 1½″ x 1″ were received at this Laboratory, in the rough condition as sheared from the strip. These plates were perfectly cleaned to insure the absence of incidental grease. They were all numbered consecutively by scratching them, and all well washed in ether and then dried at 100 degrees in an air bath for an hour. They were then taken and placed in a desiccator, and when they had reached the temperature of the room they were weighed down to one-tenth of a milligramme. The plates were then ready for test.

A series of bottles of one litre capacity, with rubber stoppers, were selected as the vessels in which to conduct these tests, and these bottles were labelled with numbers corresponding to those upon the steel plates.

These tests extended over a period of one month, at the end of which time the rust was considerable. The plates were then partially removed from the water, and the rust upon the same was easily removed by the aid of filter paper, and dropped back into the solution. The plates in this thoroughly cleansed condition were removed, washed in distilled water and finally in ether, and then placed in an air bath and dried at 100 degrees before weighing. The difference in the weight before and after these tests represents the amount of iron eaten away, or formed into rust by the action of the medium in which these plates were immersed.

TEST NUMBER 1.

Bottle No. 1 was filled with distilled boiling water, to the surface, after which the plate was placed in the bottle, and the rubber stopper securely pressed down. The cooling of the distilled water caused a slight loss of volume which left a vacuum of about ¼ inch between the surface of the liquid and the stopper.

TEST NUMBER 1-A.

The same experiment was conducted in Bottle 1-A with a current of electricity passing through the liquid.

TEST NUMBER 2.

Bottle No. 2 was filled with distilled water charged with a current of oxygen generated by heating mercuric oxide (the gas being washed in a bottle containing water); the plate was then immersed in the water and the stopper securely pressed down.

TEST NUMBER 2-A.

The same experiment was conducted in Bottle No. 2-A with a current of electricity passing through.

TEST NUMBER 3.

Bottle No. 3 was filled with distilled water and a current of ozone passed through for about thirty minutes. The ozone was generated by attaching two dry cells to a Rumkorff coil, the induced currents from which were passed to an ozone tube, the ozone being drawn over by aspiration and then passed through the water. The ozone developed by this apparatus was very strong, and the water must have absorbed or taken up considerable of the same because the odor of ozone was very apparent.

TEST NUMBER 3-A.

The same experiment was conducted in Bottle No. 3-A with a current of electricity passing through the liquid.

TEST NUMBER 4.

Bottle No. 4 was filled with distilled water charged with atmospheric air, free from all other substances, excepting oxygen and nitrogen. The atmospheric air was drawn in through a bottle containing caustic potash to absorb the ammonia and then through a bottle containing soda lime to absorb the carbon dioxide gas, and then in its pure condition, containing nothing but nitrogen and oxygen, was passed through the water.

TEST NUMBER 4-A.

The same experiment was conducted in Bottle 4-A with a current of electricity passing through the liquid.

TEST NUMBER 5.

Bottle No. 5 was filled with distilled water and atmospheric air passed through for about thirty minutes, after having been passed through a bottle containing soda lime to free it from carbon dioxide. This atmospheric air was pure with the exception of a normal percentage of ammonia gas. A current of weak ammonia gas was passed through for a second to insure the presence of same.

TEST NUMBER 5-A.

The same experiment was conducted in Bottle No. 5-A with a current of electricity passing through the liquid.

TEST NUMBER 6.

Bottle No. 6 was filled with distilled water, and atmospheric air was passed through for about thirty minutes, after having freed this atmospheric air from the ammonia, by passing it through a bottle containing caustic potash. This atmospheric air contained the normal percentage of carbonic acid. A current of carbon dioxide was passed through for a second to insure the presence of same.

TEST NUMBER 6-A.

The same experiment was conducted in Bottle No. 6-A with a current of electricity passing through the liquid.

TEST NUMBER 7.

Bottle No. 7 was filled with distilled water which was saturated with atmospheric air containing normal percentages of ammonia and carbonic acid. The plate was then immersed in this liquid.

TEST NUMBER 7-A.

The same experiment was conducted in Bottle No. 7-A with a current of electricity passing through the liquid.

The current of electricity used was very weak and was obtained from an ordinary sal ammoniac cell averaging 1½ volts, and this current was passed through a main line from which branches were made direct into the bottles and direct to the plates by contact, each plate having connection with a kathode and anode respectively. After the first day of these tests the action of the electric current was very apparent and considerable rust was observed, the water in these bottles being turned to a light yellow color, which after a month was very decided. The amount of rust observed on the plates not charged with electricity was less apparent throughout the test. For my own benefit, I placed in a bottle containing absolutely pure distilled water a small plate of steel, connected at either end with pieces of copper which were joined outside the bottle, thus forming a circuit. This test developed an amount of rust equal to that formed in any of the bottles in the foregoing tests with electricity, and I believe this was caused by galvanic action.

It is interesting to note that a casual observation of the amount of rust contained in the bottom of the bottles corresponds to the amount determined by gravimetric work.

Bottles Nos. 1 and 4 from their appearances seem to contain less oxide of iron than the other bottles with the exception of Bottle No. 5, and this is borne out as you will see by the appended data. Bottles Nos. 6 and 7 seem to contain a very large amount of oxide of iron. This is also borne out by the data. This oxide of iron in Bottles Nos. 6 and 7 has a much brighter appearance than that contained in the other bottles. In Bottles No. 5, in both cases, with or without electricity, there is very little iron oxide, and what there is seems to contain a magnetic oxide, the formula of which is Fe_3O_4, and is very dark in color. Although considerable of this

was formed it seemed to have formed upon the metal as a black coating, and evidently has served to prevent the oxidation of the iron and the formation of ferric oxide. The water in both of these bottles is very clear, with the exception of a dark sediment.

The following table will show the weight before and after test, also the amount of iron disintegrated by the action of the solution:

Test No. 1.
63.701 gm. before test
63.653 gm. after test
.0482 gm. loss

Test No. 2.
65.1831 gm. before test
65.123 gm. after test
.0601 gm. loss

Test No. 3.
63.1248 gm. before test
63.048 gm. after test
.0768 gm. loss

Test No. 4.
64.3932 gm. before test
64.344 gm. after test
.0492 gm. loss

Test No. 5.
63.0806 gm. before test
63.04 gm. after test
.0406 gm. loss

Test No. 6.
63.813 gm. before test
63.71 gm. after test
.103 gm. loss

Test No. 7.
65.5421 gm. before test
65.45 gm. after test
.0921 gm. loss

Test No. 1-A.
63.12 gm. before test
63.003 gm. after test
.087 gm. loss

Test No. 2-A.
64.7551 gm. before test
64.634 gm. after test
.1211 gm. loss

Test No. 3-A.
63.8055 gm. before test
63.69 gm. after test
.1155 gm. loss

Test No. 4-A.
65.0400 gm. before test
65.95 gm. after test
.0911 gm. loss

Test No. 5-A.
61.8858 gm. before test
61.81 gm. after test
.0758 gm. loss

Test No. 6-A.
65.6741 gm. before test
65.4800 gm. after test
.1941 gm. loss

Test No. 7-A.
63.8975 gm. before test
63.7099 gm. after test
.1876 gm. loss

FUNGUS CHECKS THE RAVAGES OF BLACK HILLS' TIMBER BEETLE.

The bark beetle which for several years has been working havoc in the valuable pine timber of the Black Hills, S. D., has apparently been given a check by a fungus which finds in the dying trees a congenial place of lodgment, and at the same time kills the beetles in the bark. There is hope that the worst of the scourge in that region is passed.

For ten years this beetle has been sweeping through the Black Hills forests, every year invading fresh areas. The total amount of pine destroyed by it is reckoned at no less than one billion feet board measure. At the present stumpage price of green timber in South Dakota this loss

would amount to $6,000,000. It now appears that its maximum destructiveness was reached about two years ago, and it is now on the decline.

Two years ago the discovery was made that a fungus was at work in the timber killed by the beetles, in which the broods were passing their infant stages preparatory to taking flight to new forests. It was noted at that time that the fungus was fatal to the young beetles, but the full extent of the work done by the fungus has just been made known in a report covering investigations of many months by the Forest Service.

The fungus is a "bark-peeler." Experts have claimed all the time that the beetles could be checked if some way could be found to peel the trees in which the young broods are harboring. They live in the inner bark and next to the wood. When the bark is separated from the wood their galleries are laid open and they die. Efforts have been made in the affected districts to peel standing trees. Machinery has been made for that express purpose, and trunks were stripped to a height of twenty feet. But so large were the affected areas that the few trees peeled were not a drop in the bucket.

Efforts were made at different times to cut the dying timber. Tracts were sold to mill men, and large quantities were cut, but not enough to have any appreciable effect on the beetle invasion. Woodpeckers helped the work along. They flocked to the dying trees by hundreds and stripped them of their bark and devoured the young beetles by the million. But that was not enough. The pest had gained such headway that it was beyond the power of barkpeelers, log cutters, and woodpeckers.

Meanwhile the peculiar fungus was gaining headway and getting in its work. It appears in the form of a grayish slime between the bark and the wood. It makes the bark loose and it falls, leaving the trees bare, and bringing down the multitudes of young beetles to their death; or, if the bark still hangs on the trunks, the effect on the beetles is equally fatal, for they die in their galleries and larvæ mines.

The habits and life history of this bark beetle render it defenseless when attacked by the fungus. The parent beetle bores a gallery several inches long in the inner layers of bark, grooving the wood. Eggs are deposited at intervals along both sides of the gallery, often as many as 60 or 70. These eggs hatch, and while in the larvæl state, they bore short galleries at right angles to the parent tunnel. They remain there a year, eating and growing. Their depredations kill the most vital part of the tree—the cambium, though the tops and needles do not succumb at once, and it is at that stage that the fungus appears and brings the career of the beetle brood to a close.

In normal conditions it probably finds a few lightning-struck trees in the proper decline to suit its purposes, or it may attack storm-thrown timber, but it is not numerous enough to kill trees, and its invasion cannot gain headway. But when some unusual condition—such as caused by a hurricane sweeping over a large timber area—provides a start, the beetles may increase in numbers until they are able to attack vigorous trees and kill them, and in fact when the epidemic is at its height they almost invariably attack living trees. That is what has happened in the Black Hills. The invasion continues until some enemy reduces the beetles below the point where they are able to kill timber. That puts an end to the invasion. This is, apparently, what the fungus is accomplishing in the Black Hills at this time.—Forest Service U. S. Dept. of Agriculture.

(Stated meeting held Thursday, March 18, 1908.)

Is the Ether a Dispersive Medium?*

By Paul R. Heyl,

Professor Central High School, Philadelphia.

In the Boyden Prize Memoir, published in the *Journal* for August, 1907, it was shown that over a range of the spectrum comprised between 468 $\mu\mu$ in the blue and 300 $\mu\mu$ in the ultra-violet the speed was constant to the extent of one point in two hundred and fifty thousand. M. Charles Nordmann has recently published (Comptes Rendus, tome 146, Nos. 6 and 8, 1908) some experimental researches which seem to prove that there is, reduced to the same terms as those of the Boyden Memoir, a difference of speed of one part in a million between the red and the blue rays of the visible spectrum. This remarkable result deserves some little discussion.

M. Nordmann's researches were based upon exactly the same method as that of the Boyden Memoir, namely, the spectrophotometric study of the star Algol near its minimum. Mr Nordmann's work was independently conceived and begun before the publication of the Boyden Memoir. Moreover, M. Nordmann confined his attention to the visible part of the spectrum, while the invisible part was the point of special attack in the Boyden Memoir.

This being the case, M. Nordmann was able to use the very accurate method of visual comparison, comparing the image of Algol and that of an artificial star through a color screen by means of a polarizing photometer. The Boyden Memoir was compelled to use a photographic method, which (according to the limit of accuracy claimed by M. Nordmann) was about twenty times less accurate, and entirely incapable of detecting a difference in speed of one part in a million. The results of these two independent investigations are therefore entirely consistent.

*Read by title.

M. Nordmann found that with Algol the minimum of the red rays occurred about sixteen minutes earlier than that of the blue rays, and about nine minutes earlier than that of the green, showing that, as in ordinary matter, the shorter waves are the most retarded.

The obvious objection to this is that the star should exhibit a change of color during its waning and waxing; but a sufficient answer to this is apparently to be found in the smallness of the effect detected by M. Nordmann and the great length (seven

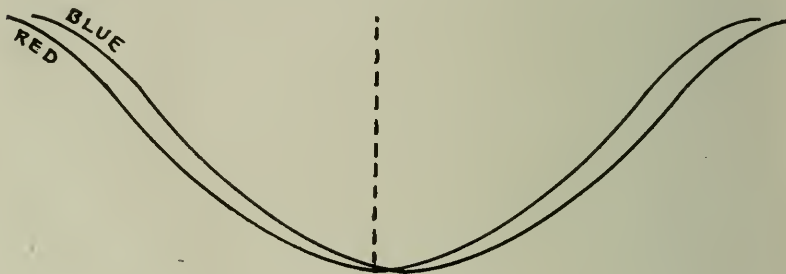


Fig. 1.

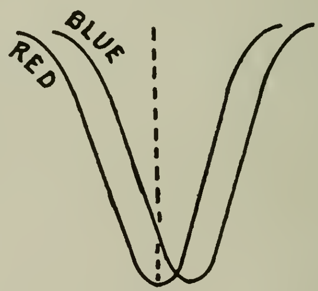


Fig. 2.

hours) of the period of variation of the star. Were the period of variation more brief and the light curve steeper, such an effect would doubtless be noticeable.

An inspection of Figs. 1 and 2 will make this clear. Fig. 1 is drawn to such a scale as to illustrate the proportionate shift of the red and blue light curves of Algol as found by M. Nordmann. It will be seen that at the red minimum the difference in intensity of the two colors is small. Fig. 2 is drawn for the same shift of minima, but a much shorter period, and it will be seen that there

is at the red minimum a much greater difference in the intensity of the two colors.

M. Nordmann has also applied his method to λ Tauri, another star of the Algol type, but fainter, and with a light curve less steep, the minimum remaining constant for about three hours. For this star he found a shift of the red and blue curves about three times as great as with Algol. Admitting the reality of this effect, it would appear that λ Tauri was at three times the distance of Algol.

Should M. Nordmann's results be confirmed by others it would by no means necessarily follow that the ether itself is a dispersive medium. M. Nordmann himself suggests the presence of dark nebulous masses scattered throughout space, and to which this slight dispersion may be due. And considering that the difference of one in a million represents a superior limit, and that owing to the uncertainty as to the parallax of Algol, the accuracy may be vastly higher, it would not seem an improbable hypothesis that the difference in speed may be due to a greater amplitude of the longer waves; that there may be in the ether an effect analogous to that in sound which causes a louder sound to travel slightly faster than a fainter one.

ALUMNI ASSOCIATION OF THE FRANKLIN INSTITUTE.

On Monday evening, April 27th, about seventy graduates of the schools of the Institute assembled in the hall for the purpose of forming an Alumni Association.

Mr. Walton Clark, President of the Institute, presided, and assured the meeting of his approval of its object, and his hearty cöoperation and that of the Board of Managers, and prophesied an interesting and important future for the association.

Mr. William H. Thorne, the Director of the Drawing School, spoke of the value of such an association, both to the graduates and to the Institute, and hoped that great care would be exercised at the beginning in the forming of the constitution and by-laws, and the selection of the officers, in order that permanency and success might be assured.

Mr. George S. Cullen, an old graduate and instructor, discussed eligibility for membership. Enthusiastic approval of the object was shown by the remarks of Messrs. Pedrick, Jones, Parsons, McCaffrey, Delaney, Fisher, Fennell and Davis, and Dr. W. H. Wahl, Secretary, and Mr. Henry Howson, Vice-President of the Institute.

On motion of Mr. Delaney, it was unanimously resolved that—It is the

sentiment of this meeting that an association of the students of the Franklin Institute be formed, and that the graduate students attendant at this meeting constitute themselves the charter members of such association.

On motion of Mr. Fennell, it was resolved that: A committee on constitution and by-laws be appointed by the President of the Institute, to consist of five members, and that Mr. Thorne be appointed chairman.

On motion of Mr. Fennell it was resolved that:

A committee of five be appointed by the President of the Institute to nominate permanent officers of the association.

The President appointed the following as the committee on constitution and by-laws: Messrs. Thorne, Parsons, Cullen, Jones and McCaffrey.

On motion, adjourned.

WM. H. THORNE, *Sec'y.*

THE FRANKLIN FUND.

The following item of interest relating to the "Franklin Fund" is contributed by Mr. Charles E. Ronaldson, member of the Board of Managers of the Institute, and a direct descendant of the James Ronaldson referred to in this note:

(Extract from the Autobiography of James Ronaldson, page 306.)

"It is interesting to note that the 'Franklin Fund' received an addition at the hands of John Scott, Chemist, living in St. Patrick's Square, Edinburgh, Scotland, who appointed James Ronaldson, of Philadelphia, Type Founder, as his true and lawful attorney for him and, in his name, as sole Executor to transfer the sum of 3000 Dollars of certain stock, to the Corporation of Philadelphia, which was entrusted with the management of the late Dr. Franklin's legacy, to be applied to the purposes of the legacy—"—From the Historical Catalogue of St. Andrew's Society, 1749-1907.

Book Notices.

PUBLICATIONS RECEIVED.

Pennsylvania State College. Annual Report for the year 1905-1906. From July 1, 1905, to June 30, 1906. Part I, Department of Instruction. Part II, Agricultural Experiment Station. 242 pages, tables, plates, 8vo. Harrisburg, State Printer, 1906.

Roosevelt and the Money Power. Responsibility of dishonest high finance for the panic of 1907, by John C. Albert. 110 pages, 16mo. New York, Sudwarth Printing Co., 1908. Paper, price, 10 cents.

The Figure and Construction of the Earth. By Prof. A. E. H. Love. Paper read before the Royal Institution of Great Britain, Friday, March 6, 1906. 15 pages, illustrations, 8vo.

The Centenary of Davy's Discovery of the Metals of the Alkalis. By Prof. T. E. Thorpe. Paper read before the Royal Institution of Great Britain, Friday, January 17, 1908. 13 pages, 8vo.

U. S. Department of Agriculture, Forest Service:
Circular 112, The Analysis and Grading of Creosotes. By Arthur L. Dean and Ernest Bateman. 44 pages, illustrations, 8vo.
Circular 117, The Preservative Treatment of Fence Posts. By Howard F. Weiss. 15 pages, illustrations, 8vo.
Circular 127, Forest Tables—Western Yellow Pine. Compiled by E. A. Ziegler. 23 pages, 8vo.
Circular 128, Preservation of Piling Against Marine Wood Borers. By C. Stowell Smith. 15 pages, illustrations, 8vo.
Circular 129, The Drain Upon the Forests. By R. S. Kellogg. 16 pages, illustrations, 8vo.
Circular 130, Forestry in the Public Schools. By Hugo A. Winkenwerder. 20 pages, 8vo.
Circular 136, The Seasoning and Preservative Treatment of Arborvitæ Poles. By C. Stowell Smith. 29 pages, illustrations, 8vo.
Circular 137, Consumption of Poles in 1906. 9 pages, 8vo.
Circular 140, What Forestry Has Done. By Treadwell Cleveland, Jr. 31 pages, 8vo.
Wholesale Lumber Prices, 1886-1898. Chart 13x17 inches.

U. S. Coast and Geodetic Survey. Terrestrial Magnetism. Results of magnetic observations made by the Coast and Geodetic Survey between July 1, 1906, and June 30, 1907. By R. L. Faris. Appendix No. 5, Report for 1907. 157-230 pages, 8vo. Washington, Government Printing Office, 1908.

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American Glass Trade Directory. Revised and complete list of glass factories in the United States and Canada. 45 pages, 24mo. Pittsburg, The Commoner Publishing Co., price, $2.00.

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U. .S. Commissioner of Education. Report for the year ending June 30, 1906, Vol. 2. 645-1308 pages, 8vo. Washington, Government Printing Office, 1908.

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